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Rio Blanco Oil Shale Project

PROGRESS REPORT 5-SUMMARY

September · October · November, 1975

Gulf Oil Corporation
and
Standard Oil Company (Indiana)
9725 East Hampden Avenue, Denver, Colorado 80231

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ERRATA: Progress Report 5 - Summary

Page 2.5.8, paragraph 3, line 5 - correct to read: "2.5.2-5 and 2.5.2-6".

Page 2.5.8, paragraph 4, line 4 - correct to read: "very small and were probably held in the fingers".

Page 2.5.13 - figure caption - correct to read:

"Figure 2.5.2-6. Blades (A to E & H) and drills (F & G) found during RBOSP archaeological survey.

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PROGRESS REPORT 5 - SUMMARY

TRACT C-a OIL SHALE DEVELOPMENT

to

AREA OIL SHALE SUPERVISOR
UNITED STATES GEOLOGICAL SURVEY

January 30, 1976

by

RIO BLANCO OIL SHALE PROJECT

Gulf Oil Corporation
and
Standard Oil Company (Indiana)

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INTRODUCTION

Rio Blanco Oil Shale Project (Gulf Oil Corporation and Standard Oil Company of Indiana), hereafter referred to in this report as RBOSP, is presenting it's fifth summary progress report for Tract C-a to the USGS Area Oil Shale Supervisor (AOSS). This report is a summary of work accomplished during the period September 1, 1975 through November 30, 1975. The baseline data gathered for the project are on file in the Area Oil Shale Supervisor's Office in Grand Junction, Colorado. These data and its interpretive text comprise Progress Report 5. This summary report presents an overview and highlights of these data and has been correlated to and organized consistent with Progress Report 5; that is, the numbering system and topic headings for the summary report is the same as that used in the Progress Report. For more detailed information the reader should refer to the Progress Report.

As has been done for Progress Reports 2 through 5, the numbering system for this report is consistent with those of the previous reports. Therefore, a reader desiring information on the same subject in the previous reports (both Summary and Progress Reports) will find it under the same title heading and number. If information has not changed since the previous reports, i.e., objectives, methods, or results, the reader is referred to the appropriate report.

It should be noted that results of data taken during this quarterly reporting period but not available in time for this Progress Report will be included in the ensuing reports.

In keeping with the policy established in Progress Report 4 - Summary, abstracts of the Geotechnical and Environmental Baseline sections are included in this report. They are located immediately behind the appropriate section divider sheet. Previously, Progress Reports 2, 3 and 4 - Summaries included appendices which summarized the work being done for the Detailed Development Plan (DDP). This is not being done in this report because drafts of most sections of the DDP have recently been submitted to the AOSS and Oil Shale Environmental Advisory Panel (OSEAP).

In addition to the interpretive text and data for this quarter which comprise Progress Report 5, other information is being submitted as part of this Progress Report. For geology, a detailed Geologic Report of Tract C-a is being submitted. The information that is considered proprietary by RBOSP is submitted under separate cover in a confidential volume. The DDP input is based on this report. For hydrology, continuous data collected at stream gaging stations is reported for the 1975 water year.

Detailed annual reports are being submitted for the baseline Terrestrial and Aquatic studies. The baseline DDP input is being summarized from these reports and will reference this and the Progress Report. For the Air Quality and Meteorology sections, data from December 1975 and January 1976 will be incorporated into an annual report which will be submitted to the AOSS in early March 1976. This report will be the input to the DDP.

For general informational purposes in this report, two figures are shown. Figure 1 is a location map of Tract C-a showing major drainages, roads, towns and counties in the vicinity of the tract. Figure 2 shows Tract C-a in greater detail and generally locates the drill holes, stream gaging stations, air quality towers and roads.

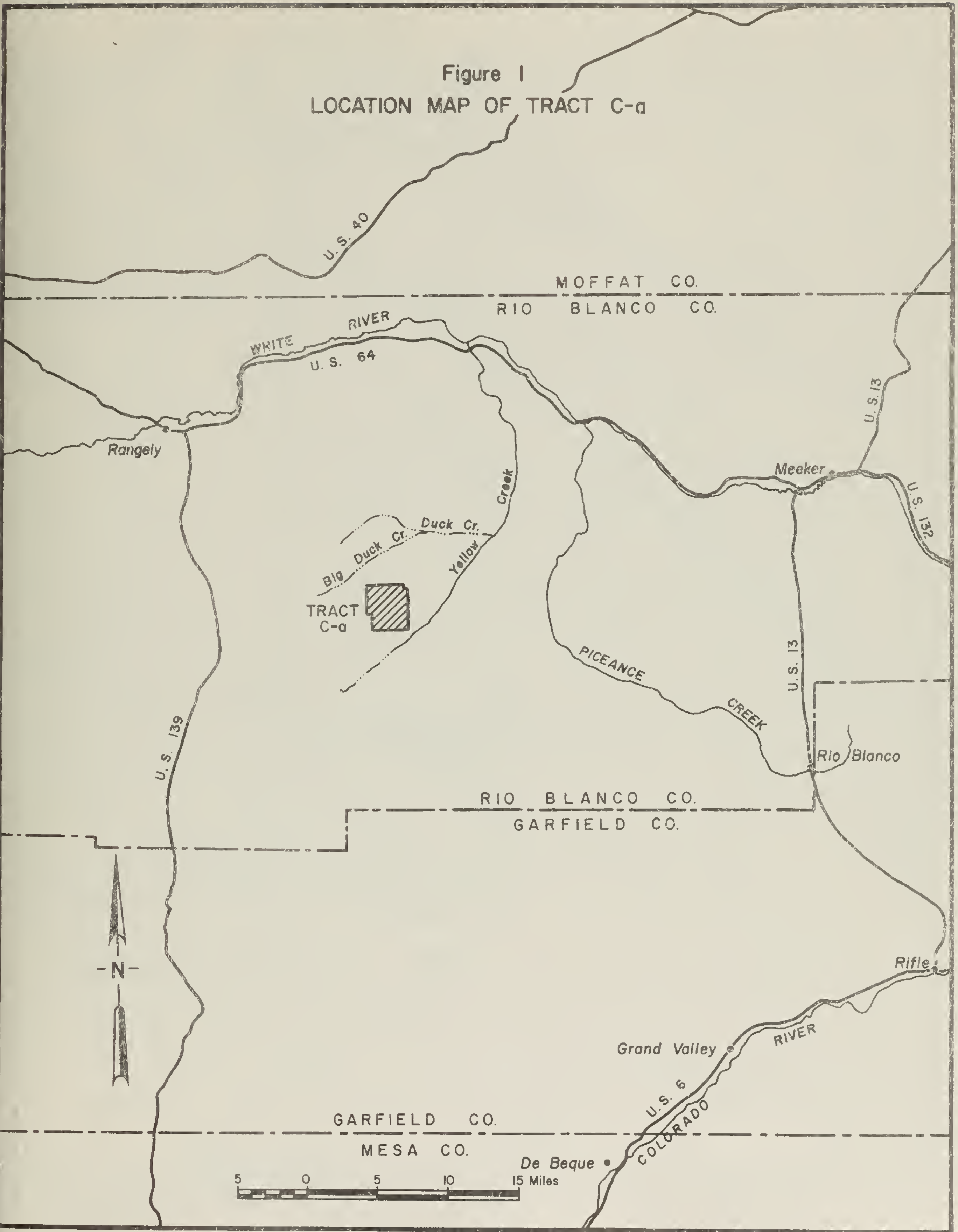
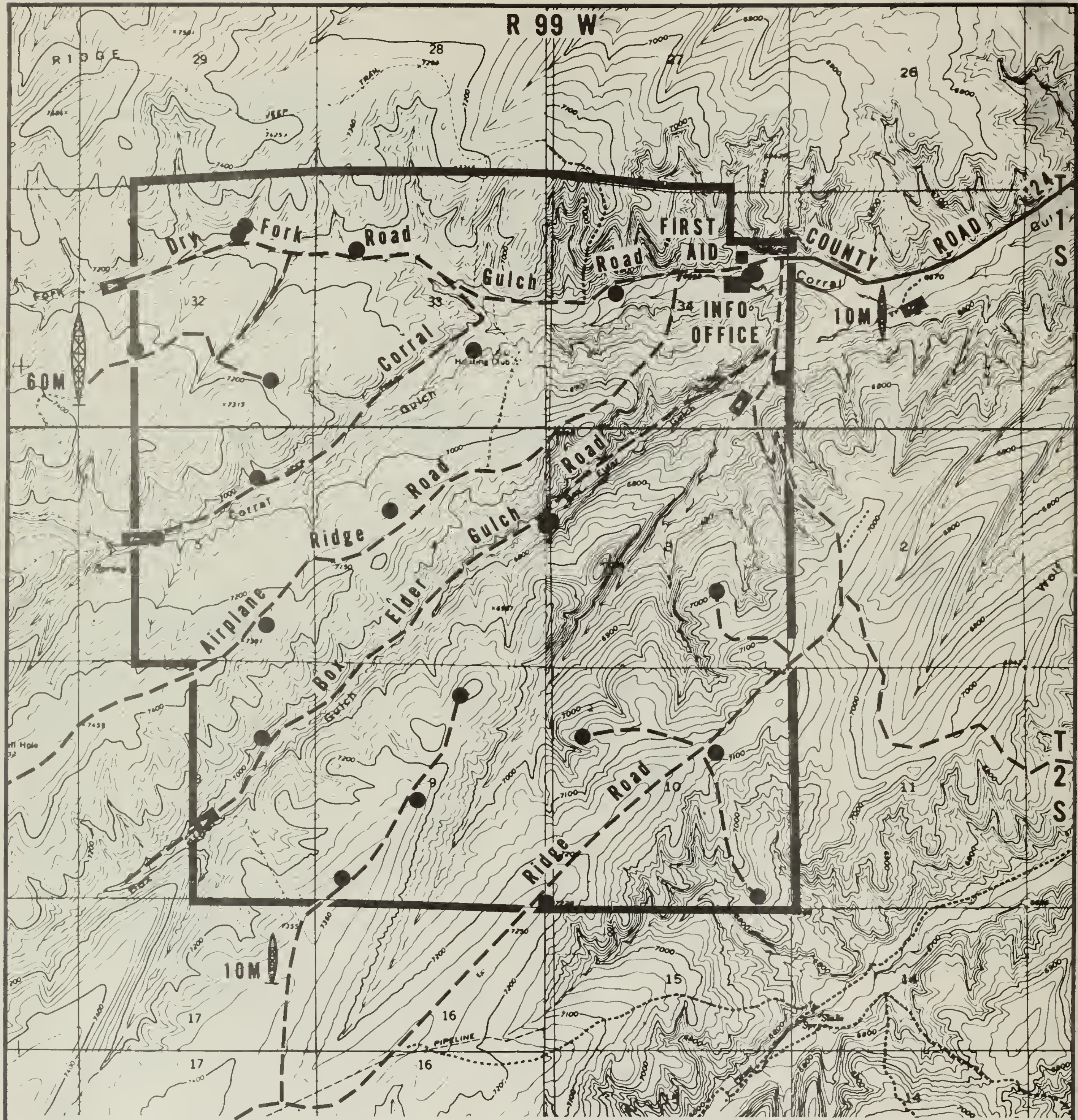


Figure 1
LOCATION MAP OF TRACT C-a



LEGEND

- ▬ TRACT OUTLINE
- ● DRILL HOLES
- ■ STREAM GAGING STATIONS
- AIR QUALITY TOWERS
- ═ ROADS

FIGURE 2

GULF - STANDARD (INDIANA)

RIO BLANCO OIL SHALE PROJECT

TRACT C-a

RIO BLANCO COUNTY, COLORADO

0 3000

Geotechnical Data Gathering Project

ABSTRACT

RBOSP initiated the Geotechnical Data Gathering Project, which consists of the Geologic Program and the Hydrologic Program, in the spring and summer of 1974. The project provides the data required for detailed engineering studies as well as the data necessary to establish baseline conditions. This progress report updates the status of each of the programs for the period September through November 1975.

Activity relating to the Geologic Program during the quarterly reporting period concerned reclamation of drill sites, continued reassaying of samples from coreholes G-S 6 and G-S 4-5, and completion of the final report for rock mechanics.

Reclamation of the drill site as specified by the Area Oil Shale Supervisor has generally consisted of: cleanup and grading of drill site; scarifying of drill sites in preparation for seeding; seeding with one of three different seed mixtures; dragging the seeded area lightly with chains; and fencing those locations as specified by the Area Oil Shale Supervisor.

During the quarterly reporting period activity under the Hydrologic Program included: completion of the four additional stream gaging stations; finalizing continuous stream gaging data for the 1975 water year (October 1974 - September 1975); and the ongoing monitoring and sampling of the various streams and holes in the Tract C-a vicinity.

Five stream gaging stations reported flow during the quarterly reporting period. The "lower" Big Duck Creek stream gaging station (one of the five reporting flow) did not report complete data and therefore the stream data has been omitted from this report. Data from the "lower" Big Duck Creek gaging station will be updated in ensuing reports. The other four stations reporting flow during the quarterly reporting period are listed below with the average total dissolved solids for the portion of the reporting period for which data was available.

Stream Gaging Station	Total Dissolved Solids (mg/l)
Corral Gulch Near West Line Tract C-a	760
Corral Gulch East of Tract C-a	840
Corral Gulch Near 84 Ranch	1,280
Yellow Creek Near White River	2,600

Precipitation from the three reporting storage type rain gages averaged a little over 3/4 inch per month during the 3 months of the quarterly period. Most of the precipitation fell during October and November, averaging nearly one inch per month for these two months.

This progress report considers yearly data as continuous data from the stream gaging station for the 1975 water year (October 1974 - September 1975) are now available. This data helps define seasonal trends in the hydrologic cycle important in establishing baseline conditions.

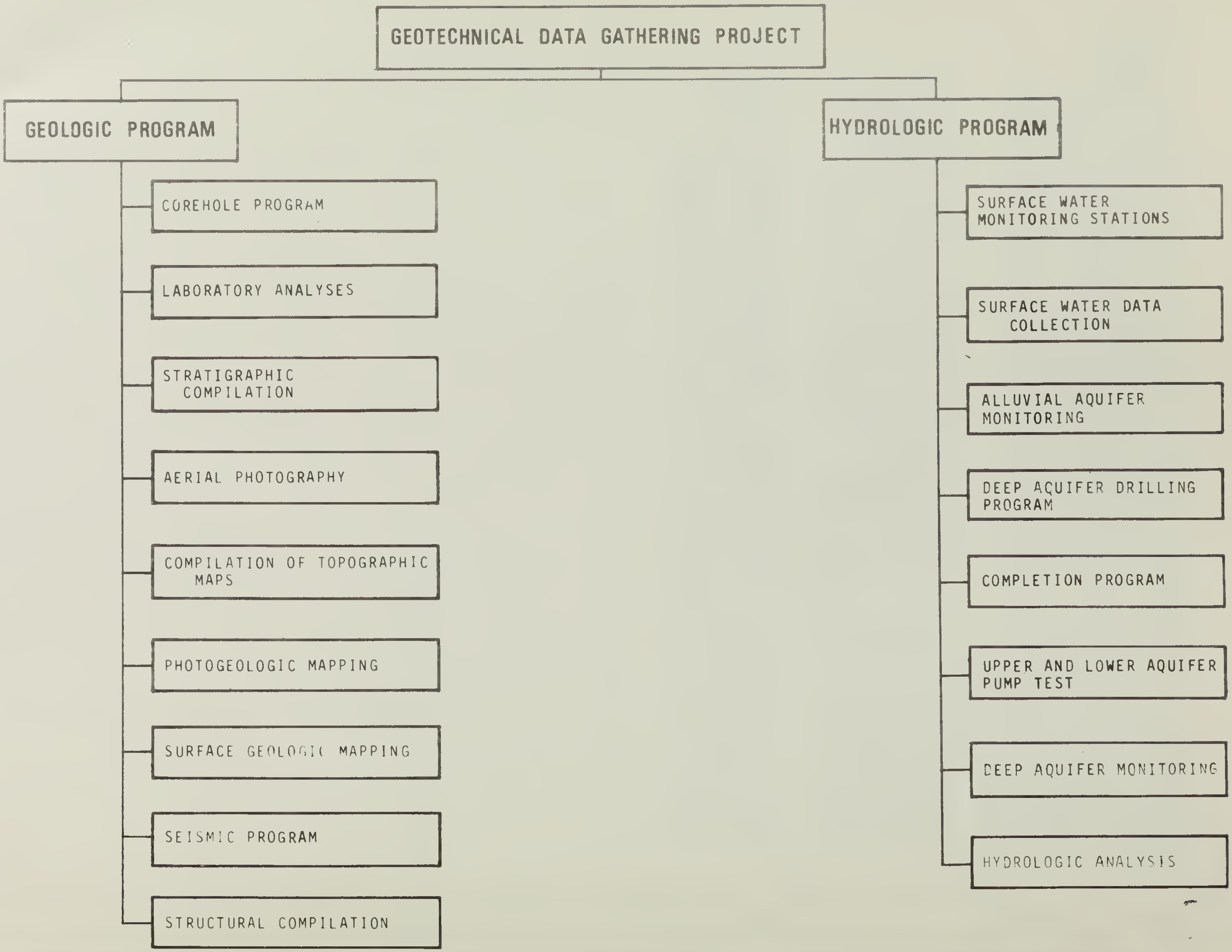
1.0 GEOTECHNICAL DATA GATHERING PROJECT

The Geotechnical Data Gathering Project has been subdivided into two programs which are the Geologic Program and the Hydrologic Program. Each of the programs has been subdivided into tasks which must be performed in order to provide the data necessary to formulate the Detailed Development Plan and establish baseline conditions. Figure 1.0-1 illustrates the project breakdown of the Geotechnical Data Gathering Project.

Major portions of the tasks making up the Geologic Program were completed prior to this reporting period. Tasks making up the program which required effort during the quarter were the Corehole Program, Laboratory Analysis, Aerial Photography, Compilation of Topographic Maps, and Structural Compilation. The status of each of the Geologic Program tasks are described under the specific task heading.

Activity under the Hydrologic Program consists of continued monitoring and the completion of four additional stream gaging stations. Continuous data have been received from the USGS-WRD for the 1975 water year and are presented in this progress report. The status of each particular task is described under the specific task heading.

Figure 1.0-1


GEOTECHNICAL DATA GATHERING PROJECT
GEOLOGIC PROGRAM
COREHOLE PROGRAM
LABORATORY ANALYSES
STRATIGRAPHIC COMPILATION
AERIAL PHOTOGRAPHY
COMPILATION OF TOPOGRAPHIC MAPS
PHOTOGEOLOGIC MAPPING
SURFACE GEOLOGIC MAPPING
SEISMIC PROGRAM
STRUCTURAL COMPILATION
HYDROLOGIC PROGRAM
SURFACE WATER MONITORING STATIONS
SURFACE WATER DATA COLLECTION
ALLUVIAL AQUIFER MONITORING
DEEP AQUIFER DRILLING PROGRAM
COMPLETION PROGRAM
UPPER AND LOWER AQUIFER PUMP TEST
DEEP AQUIFER MONITORING
HYDROLOGIC ANALYSIS

1.1 Geologic Program

The nine major tasks which make up the geologic program are as follows: Corehole Program, Laboratory Analyses, Stratigraphic Compilation, Aerial Photography, Compilation of Topographic Maps, Photogeologic Mapping, Surface Geologic Mapping, Seismic Program, and Structural Compilation. Most of these tasks had been completed prior to this reporting period and reported in previous Progress Reports. During this reporting period the reclamation of drill pads, was finished with the fall seeding, reassays of some of the core intervals were being conducted. Areal photography of 84 Mesa was completed, as was preliminary topographic mapping of 84 Mesa. A detailed Geologic Report of Tract C-a is being submitted as part of Progress Report 5 - Interpretive Text. The results of the rock mechanics program is submittal to the Area Oil Shale Supervisor in the RBOSP Progress Report 5 - Confidential Volume.

1.1.1 Corehole Program

A description of the corehole program was presented in RBOSP Progress Report 2 - Summary. Figure 1.1-1 is a map of Tract C-a showing the pre-lease corehole as well as the location of Gulf-Standard (Indiana) coreholes drilled during the summer and fall of 1974. Work conducted in conjunction with the corehole program during the quarterly reporting period (September, October, and November) consisted of drill site reclamation as described in the following paragraphs.

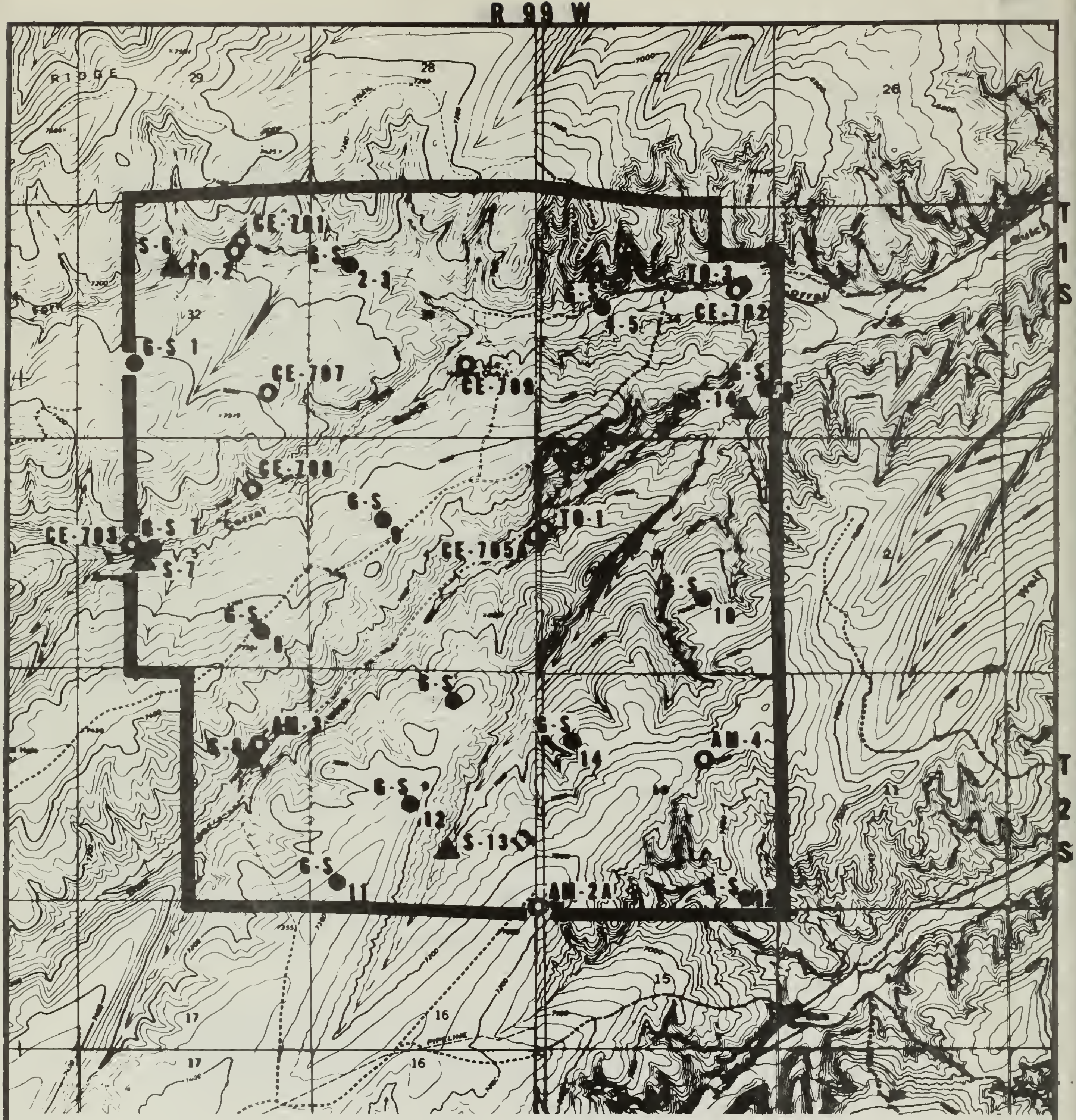
Some drill site reclamation was completed in October of 1974, in areas where drilling and associated activities were basically completed. Results of this effort were inspected in April 1975, and work required by the AOSS to complete reclamation was set forth.

In summary, some eighteen new drill sites were created for the RBOSP 1974-75 geotechnical drilling program; three pre-lease drill sites were disturbed anew for additional RBOSP holes. This resulted in twenty one drill sites for which reclamation was specified and completed generally as follows:

1. Drill and coreholes were marked. Waste from the drilling operation was removed. The disturbed area was then reshaped to a contour commensurate with the surrounding topography; a flat area was left around holes in which further completion work will be done.

2. Prior to seeding the area was prepared by ripping.

3. Seeding was accomplished mainly by a tractor-drawn seed drill; seeding was done by hand in a few small areas to complete seeding or in areas not reached by the drill. One of three different seed mixtures was used.



GULF - STANDARD (INDIANA)

RIO BLANCO OIL SHALE PROJECT

TRACT C-a

COREHOLE PROGRAM

PRE-SALE CORE HOLES

CE○ CAMERON

TO○ TOSCO

AM○ AMOCO

POST SALE CORE HOLES

G-S● GULF - STANDARD

S-6▲ ALLUVIAL AQUIFER TEST WELL

FIGURE 1.1-1

4. The seeded area was drug lightly with chains after seeding. No fertilizer or watering was used.

5. Fencing of thirteen of the new RBOSP drill pads was completed as required by the AOSS. Standard three-strand barbwire range fence was used.

Further details of the present status of the subject drill sites is reported in Table 1.1-1.

It is believed that the subject drill pads have been reasonably reclaimed at this point. An inspection will be made around May or June 1976, to determine the viability of the seeding.

Required reclamation of drill sites at G-S 6, G-S D18, and the access road to G-S 14 will be completed either in 1976 or when they are no longer in use. Drill site reclamation at G-S M5 will be completed during 1976.

1.1.2 Laboratory Analyses

The general objectives of these programs were summarized in Section 1.1.2 of Progress Report 4 - Summary. During this reporting period oil shale core intervals from G-S 4-5 and G-S 6 were being reassayed. Also, assaying of intervals of core withheld from assay for rock mechanics testing was begun. A final report on the rock mechanics test was completed.

1.1.2.1 Oil Shale Assays

Re-assay of core intervals in the lower portions of G-S 4-5 and G-S 6 not yet completed. Anticipate results will be available for Report 6. Assaying of some core intervals previously withheld for rock mechanics testing has begun. This new data will be submitted to AOSS as available in subsequent progress reports. The entire core from G-S 13 is still withheld from assaying in the event that additional rock mechanics testing requiring complete core is necessary.

1.1.2.2 Nahcolite Analysis

The results of the nahcolite analyses were submitted to the AOSS as described in Section 1.1.2.2 of RBOSP Progress Report 2 - Summary.

1.1.2.3 Extractable Alumina

The results of the extractable alumina analyses on processed shale was submitted to AOSS in Section 1.1.2.3 of Progress Report 2 - Interpretive Text. The concentration of extractable alumina in processed shale was found to vary considerably with stratigraphy. RBOSP is continuing to study the commercial potential of alumina extraction consistent with the development of Tract C-a.

Table 1.1-1

STATUS OF DRILL SITE RECLAMATION

Drill Site-Hole Numbers	RBOSP (RB) or Pre-lease(PL)	Seed Mixture* Used	Fencing	Other Reclamation
G-S 1	RB	SM-1**	Yes	
G-S 2-3	RB	SM-2**	Yes	
G-S 4-5	RB	SM-2; Reseed SM-3	Yes	
G-S 6	RB	Not seeded yet; storage supply area	Yes	
G-S 7	RB	SM-2	Yes	Some sagebrush slash covering
G-S 8	RB	SM-1; reseeded SM-3	Yes	
G-S 9	RB	SM-1**	Not required	
G-S 10	RB	SH-1; Reseed SM-3	Not required	
G-S 11	RB	SM-3	Yes	
G-S 12; G-S D-16	RB	SM-3	Yes	
G-S 13	RB	SM-1	Not required	Slash covering
G-S 14	RB	SM-1	Yes	
G-S 15	RB	Not required. Too rocky.	Not required	Slash covering
G-S M-1	RB	SM-3	Yes	Slash covering
G-S M-2	RB	SM-3	Yes	
G-S M-3	RB	SM-3**	Yes	
G-S M-4	RB	SM-3***	Yes	Slash covering
G-S M-5	RB	Not seeded yet	Not fenced	
G-S D-17	PL	SM-3	Prev. fenced	
G-S D-18	PL	Not seeded yet; headquarters site	Not fenced	
G-S D-19	PL	SM-3	Prev. fenced	

*Seed Mixtures (SM) Used:

SM-1	SM-2	SM-3	lbs/acre
40% Western Wheatgrass	90% Western Wheatgrass	Winterfat	1.5
5% Annual Rye	10% Annual Rye	Lewis Flax	1.0
15% Big Sage		Luna Pubesent Wheat Grass	2.5
10% Bitterbrush		Oahe Intermediate Wheat Grass	2.5
20% Beardless Wheatgrass		Forwing Saltbush	0.5
10% Needle & Threadgrass		Sand Dropseed	1.0
100%	100%		
8 lbs/acre	8 lbs/acre		9.0

**Small areas 50' x 100' around hole seeded subsequently with SM-3.
***Missing Lewis flax seed from mixture; ran short of supply.

1.1.2.4 Trace Elements

The analyses of seven trace elements in fresh and processed oil shale samples were reported in Section 1.1.2.4 of RBOSP Progress Report 2 - Summary. The mineral identification and occurrence of the same seven trace elements were reported in RBOSP Progress Report 3 - Summary.

1.1.2.5 Gas Samples

The gas sampling program has been completed and was reported in Section 1.1.2.5 of RBOSP Progress Report 2 - Summary.

1.1.2.6 Rock Mechanics

An extensive rock mechanics program was initiated during the exploration phase of this project to determine the rock mechanics parameters essential for mine design. Rock mechanics parameters for mine design were determined primarily by laboratory tests of core from G-S core holes 2-3, 4-5, 6, 11 and 15. A report by RE/SPEC Inc., "Final Summarization and Analysis of Laboratory Rock Mechanics Test Data For Core Samples From Oil Shale Lease Tract C-a" contains the results of the rock mechanics program. This report is submitted to the Area Oil Shale Supervisor in Section 1.1.2.6 of the Confidential Volume of Progress Report 5.

The following rock properties, considered important for mine design, were obtained from testing of cores and geophysical logging.

- Uniaxial compressive strength
- Modulus of elasticity
- Tensile strength
- Angle of internal friction
- Cohesion
- Rock density
- Shear strength
- Modulus of rupture
- Poission's ratio
- Dynamic Elastic Properties

Laboratory test results for uniaxial compressive strength, tensile strength, modulus of elasticity, modulus of rupture and angle of internal friction were correlated with ore grade, irrespective of zone. In addition to these analyses, the test results from core from only the Mahogany zone were correlated with ore grade.

Information regarding the in situ rock characteristics was obtained from surface geologic mapping, seisviewer logs and core logs from which the nature, number and orientation of major joints were determined to the extent possible with the available data. The in situ rock stresses were utilized from published information on hydrofracture tests made by the U.S. Geological Survey in drill holes CE 702 and CE 703.

Following is a discussion of the various individual rock strength parameters utilized during the Phase I mine studies.

1.1.2.6.1 Uniaxial Compressive Strength

The uniaxial compressive strength of oil shale has been shown in the past to be directly related to oil shale grade. Compressive strength decreases with an increase in oil shale grade. It is noted that compressive strength, irrespective of zone on Tract C-a, appears to be generally lower than the compressive strength of the Mahogany zone at Anvil Points and Colony Mines. Also, the Mahogany zone compressive strength appears to be higher than in the case where all zones are considered. In all cases, compressive strength appears to become constant in the range of 34 to 40 GPT.

The reason for the apparent difference between rock strength and ore grade by zone and irrespective of zone is not known. The difference may be related to the detailed mineralogy of the various mining horizons which contain varying minor amounts of nahcolite and dawsonite as well as various clay minerals.

1.1.2.6.2 Modulus of Elasticity

The modulus of elasticity also decreases with increasing oil shale grade between 0 and 45 GPT. The modulus of elasticity values for Tract C-a were plotted irrespective of zone. Sufficient data were not available for determination of the ore grade-modulus relationship by zone except for the Mahogany zone, where the modulus of elasticity tends to be higher than in the case where all zones are considered.

It is to be noted that the modulus of elasticity for all zones within Tract C-a is significantly lower in the low oil content range than in the Mahogany zone at Anvil Points. The reason for this apparent differences is not known, but as in the case of the compressive strength, the difference is possibly related to mineralogy.

1.1.2.6.3 Tensil Strength

Tensil strength was determined by Brazil splitting tests of core samples. Tensile strength appears to increase with oil content between 0 and 28 GPT. At approximately 28 GPT, tensil strength values become almost constant.

1.1.2.6.4 Angle of Internal Friction - Intact Rock

Sufficient data are available to correlate oil content with the angle of internal friction for intact rock in the range between 10 and 45 GPT. This angle ranges from near 43° at 10 GPT to 25° at 45 GPT.

1.1.2.6.5 Angle of Internal Friction - Rock Joints

Tests on rock samples containing planes of weakness are limited. The results of the tests indicate that the strength of jointed rock is quite high, possibly in the general range of intact or unjointed rock. The average coefficient of sliding friction, as determined from test results, is about 0.7 or an angle of internal friction of 35°, for both open and sealed joints.

1.1.2.6.6 Cohesion

The limited testing of Tract C-a rock samples containing sealed joints indicates cohesion may average about 250 psi.

1.1.2.6.7 Density

The relation between oil content and grain density has been well established by investigators in the Piceance Creek basin. The best known curve for oil content-density is the John Ward Smith curve (described in "Specific Gravity - Oil Yield Relationships of Two Colorado Oil Shale Cores", Industrial and Engineering Chemistry, Vol. 48, No. 3, pp. 441-444) developed by the U.S. Bureau of Mines. From density determinations of Tract C-a core, it was found that a modification of the John Ward Smith relationship gave a better data fit to Tract C-a conditions.

1.1.2.6.8 Shear Strength

No definite relationship has been established between oil shale grade and shear strength of Tract C-a oil shale. Laboratory test values from triaxial tests were found to range from 2505 to 3950 psi. The average value from direct shear tests for the peak shear strength of intact samples is as high as 2350 psi. The shear strength parallel to the stratification in oil shale appears to be higher than the post mining lateral stresses present. The average residual shear strength from direct shear tests on intact samples is 825 psi.

1.1.2.6.9 Modulus of Rupture

This rock strength parameter was also determined, although it was not used directly for any design analysis of open pit mine slopes. A conservative value for the modulus of rupture of two times the tensile strength parallel to the oil shale bedding has been used for design. However, on Tract C-a the modulus of rupture has proved to be 3 to 4 times the tensile strength.

1.1.2.6.10 Poisson's Ratio

Testing has shown Poisson's ratio to be independent of oil shale grade and highly dependent on stress levels during testing. Poisson's ratios were also determined for discrete zones within the mining sequence for use in finite element analysis of pit slopes.

1.1.2.6.11 Dynamic Elastic Properties

The above properties which have been established for oil shale are all static properties. In order to determine in situ elastic properties utilizing Birdwell borehole velocity logs, a number of dynamic tests were performed on core samples to establish a ratio between the static and dynamic elastic properties. The ratio of static to dynamic modulus of elasticity generally increases with depth. As expected, the dynamic elastic constants are greater than the static elastic constants. If no in situ measurements are available, the in situ static modulus of elasticity and Poisson's ratio will be taken as 0.43×10^6 psi and 0.37 respectively, for the Mahogany zone.

1.1.3 Stratigraphic Compilation

The stratigraphic compilation has been completed and was reported in Section 1.1.3 of RBOSP Progress Reports 3 and 4 - Summaries. In addition, six oil shale assay histogram cross sections and six density log cross sections are included in Section 1.1.3 of the Confidential Volume of Progress Report 5.

1.1.4 Aerial Photography

Aerial photography of an additional 8,200 acres covering the 84 Mesa area north of Tract C-a has been completed. These photographs have been used in the detailed topographic mapping of the 84 Mesa area.

1.1.5 Compilation of Topographic Maps

Preliminary mapping using the photographs mentioned in Section 1.1.4 has been completed and is presently being checked for accuracy. These will be submitted to the AOSS when finalized.

1.1.6 Photogeologic Mapping

Photogeologic mapping has been completed as reported in Section 1.1.6 of RBOSP Progress Report 2 - Summary.

1.1.7 Surface Geologic Mapping

The surface geologic mapping of about ten square miles has been completed as was reported in Section 1.1.7 of Progress Report 2 - Summary.

1.1.8 Seismic Program

The seismic program was discontinued as reported in Section 1.1.8 of RBOSP Progress Report 2 - Summary.

1.1.9 Structural Compilation

A revised Middle A-groove structure map (Revision 1) is enclosed in Section 1.1.9 of the Confidential Volume of Progress Report 5. Two additional faults recently located in the northwest corner of Tract C-a have been added to this map. Revisions also include minor changes to interpretations of several other faults.

1.2 Hydrologic Program

Rio Blanco Oil Shale Project is conducting a surface and subsurface Hydrologic Program on and around Tract C-a to collect the data needed to establish baseline hydrologic conditions. The program covers phases from the initial exploration to the hydrologic summary and analysis. This data is required for the design of the mine dewatering system and information required for acquisition of ground water rights.

The Hydrologic Program consists of eight specific tasks, which are reviewed and analyzed during the quarter. RBOSP Progress Report 2 presented hydrologic data collected during the core hole drilling program; Progress Report 3 presented data obtained during the formal pumping tests. Progress Report 4 contains data obtained from the monitoring program and a hydrologic interpretive analysis. Progress Report 5 updates the data from the hydrologic monitoring from September through November 1975.

RBOSP submits the data generated from the program in two parts: Progress Report 5 - Interpretive Text and Progress Report 5 - Raw Data. Following is a summary of the status and update of each hydrologic task.

1.2.1 Surface Water Monitoring Stations

RBOSP has contracted with the Colorado River Water Conservation District to have the Water Resources Division of the U.S. Geological Survey construct and monitor eleven stream gaging stations and six rain gaging stations. RBOSP Progress Reports 2 and 3 described the operation of the stream gaging stations. The major activity under the Hydrologic Program during this quarter was the completion, by October 1, 1975, of four additional stream gaging stations located near 84 Mesa. The locations of the four new stations were described in Progress Report 4 - Summary.

Table 1.2-1 shows the USGS identification number and Figure 1.2-1 shows locations of each of the eleven stream gaging stations and the six rain gaging stations. Figure 1.2-1 also shows the location of the alluvial monitor holes. Table 1.2-2 shows the data collection schedule for the surface gaging stations.

The continuous and automatically recorded data for the 1975 water year (October 1, 1974 - September 30, 1975) have been recieved from the USGS. These data included continuous stream flow, temperature, specific conductance, and automatic sediment discharge. In addition, rainfall intensity data were also received for the first time.

1.2.2 Surface Water Data Collection

Previous surface hydrologic data submitted by the U.S. Geological Survey were presented in Progress Reports 2, 3 and 4. RBOSP Progress Report 5 contains continuous surface water data for the water year

TABLE 1.2-1

LOCATION AND USGS IDENTIFICATION NUMBERS FOR STREAM AND RAIN GAGING STATIONS
Tract C-a and Vicinity

USGS Identification number	Location
09306237	Dry Fork near west line Tract C-a
09306235	*Corral Gulch near west line Tract C-a
09306240	Box Elder Gulch near west line Tract C-a
09306242	*Corral Gulch east of Tract C-a
09306230	Stake Springs Draw near confluence with Corral Gulch
09306255	*Yellow Creek near White River, Colorado
09306241	"Rinky Dink" Gulch near east line Tract C-a
09306248	Upper Big Duck Creek north of 84 Mesa
09306250	*Lower Big Duck Creek north of 84 Mesa
09306246	Tributary to Yellow Creek east of 84 Mesa
09306244	*Corral Gulch near 84 Ranch
	Storage-Type Rain Gages
09306235	Corral Gulch near west line Tract C-a
09306237	Dry Fork near west line Tract C-a
09306240	Box Elder Gulch near west line Tract C-a
	Rainfall Intensity and Recording Rain Gage
09306230	Stake Springs Draw near confluence with Corral Gulch
09306255	Yellow Creek near White River, Colorado
No number	Cathedral Bluffs located in NW 1/4, NW 1/4, Section. 14, T2S, R100W

*Stream gaging stations reporting flow during the quarterly reporting period (September, October and November 1975).

Figure 1.2-1
STREAM GAGING STATIONS,
RAIN GAGING STATIONS
AND
ALLUVIAL AQUIFER MONITORING HOLES

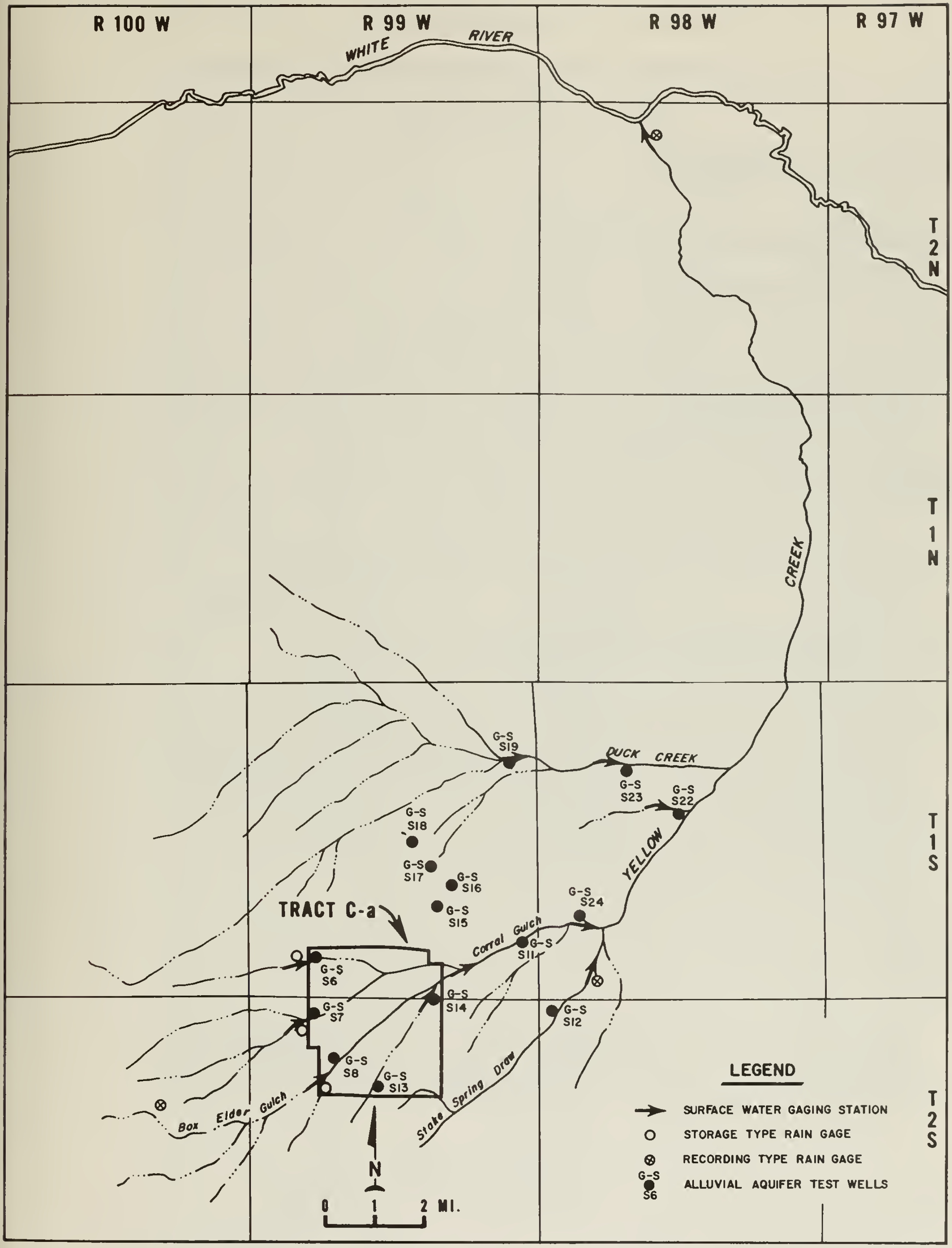


Table 1.2-2

DATA COLLECTION SCHEDULE FOR STREAM GAGING STATIONS

TRACT C-a AND VICINITY

Continuously or Automatically

- Flow Rate
- Sediment Discharge
- Temperature
- Specific Conductance

Periodically

- Storage Rain Gages
- Recording Rain Gages
- Rainfall Intensity Gages

Semi-Monthly

- Barium
- Boron
- Calcium
- Chromium (Hexavalent)
- Copper
- Fluoride
- Iron
- Lithium
- Magnesium
- Potassium
- Selenium
- Silica
- Sodium
- Sulfate
- Zinc
- Ammonia
- Bicarbonate
- Carbonate
- Chloride
- Color
- Dissolved Solids
- Kjeldahl Nitrogen
- Nitrate
- Nitrite
- Odor
- Oil and Grease
- Turbidity
- Dissolved Oxygen
- pH
- Arsenic
- Cadmium
- Lead
- Manganese
- Mercury
- Total Phosphate
- Ortho Phosphate
- Cyanide
- Sulfide

Quarterly

- COD
- Fecal Coliform
- Pesticides
- Polycyclic Aromatics
- Radioactivity
  - Gross Alpha
    - 4 Picocuries/l
    - Ra^{226}
  - Gross Beta
    - 100 Picocuries/l
    - Th^{230}
    - Uranium
- Spectrographic Scan
  - 67 Elements
- TOC
  - 10 mg/l
  - DOC
  - SOC
  - Phenols
  - Sulfur
  - Nitrogen

1975 (October 1, 1974 - September 30, 1975). These data include continuous stream flow, temperature, conductivity.

Sediment concentration and sediment discharge records are available for the following four stream gaging stations: Box Elder Gulch near the west line of Tract C-a, Corral Gulch east of Tract C-a, Corral Gulch near the west line of Tract C-a, and Yellow Creek near White River. The sediment data is reported in the Interpretive Text portion of Progress Report 5. Continuous hydrologic data, now available for the 1975 water year (October 1, 1974 - September 30, 1975), replaces the previous semi-monthly instantaneous data and are included for the first time in Progress Report 5 - Interpretive Text. Continuous data is reported as a mean value of daily fluctuations. Where continuous data is either lacking or has not as yet been reported instantaneous data is discussed. In addition, instantaneous water quality data from two of the four new gaging stations associated with 84 Mesa were received. The data from the Lower Big Duck Creek gaging station were incomplete and therefore were not included. The data from the Corral Gulch near 84 Ranch gaging station are complete and have been included. The other six gaging stations associated with Tract C-a and 84 Mesa remained dry during the quarter. Table 1.2-1 indicates those stations reporting flow during the quarter. Discussion of data from those stream gaging stations which reported flow during the 1975 water year (October 1, 1974 - September 30, 1975) is presented in the following paragraphs.

The Box Elder Gulch stream gaging station reported continuous flow from only April 30, 1975 to July 3, 1975 during the 1975 water year which was apparently the result of spring snow melt and runoff. The snow melt runoff peaked in July 1975 at 2.9 cfs. Two other short periods of flow were recorded in mid-July and August the result of runoff from thunderstorm precipitation. The mean conductivity measured at the Box Elder Gulch stream gaging station averaged slightly less than 900 umhos/cm for the period of flow during the snow melt runoff. The mean conductivity of the brief flows during the runoff of thunderstorm precipitation was quite a bit higher at approximately 1230 umhos/cm. Boron and fluoride values averaged approximately 0.9 mg/l and 0.3 mg/l respectively for the period during the snow melt runoff (April 30, 1975 - July 3, 1975). The boron and flouride concentration measurements are the result of analysis of instantaneous samples collected during a flow. Samples from the stream flows that are a result of local thunderstorms are often missed because of the brief period of flow for such events. Plots of data from the Box Elder Gulch stream gaging station are presented in Progress Report 5 - Interpretive Text. A summary of water quality analysis for the Box Elder Gulch station is presented in Table 1.2-3.

The stream gaging station on Corral Gulch located near the west line of Tract C-a had a maximum discharge of 0.64 cfs in June 1975, which declined to 0.1 cfs by mid-July. The discharge rate then increased and fluctuated between 0.2 or 0.4 cfs through the end of the 1975 water year (September 30, 1975). Conductivity generally averaged

TABLE 1.2-3

SUMMARY WATER ANALYSIS RBOSP
STREAM GAGING STATION, USGS 09306240
BOX ELDER GULCH NEAR WEST LINE TRACT C-a

	/14/75	5/28/7	6/16/7	6/25/75								
1. Alkalinity (mg/l)	257	290	267	274								
2. Aluminum (ug/l)												
3. Ammonia (mg/l)	.01	.00	.00	.00								
4. Aromatics, Polycyclic												
5. Arsenic (ug/l)	8	5	5	3								
6. Barium (ug/l)	100	0	100	0								
7. Beryllium (ug/l)												
8. Bicarbonate (mg/l)	313	354	326	334								
9. Bismuth (ug/l)												
10. Boron (ug/l)	100	110	80	70								
11. Cadmium (ug/l)	0	0	0	0								
12. Carbonate (mg/l)	0	0	0	0								
13. Carbon Dioxide (mg/l)	1.6	---	.5	.8								
14. Chloride (mg/l)	6.0	5.2	5.2	6.0								
15. Chromium (ug/l)	20	0	0	0								
16. Cobalt (ug/l)												
17. COD												
18. Coliform, Total & Fecal												
19. Color (PVC)	9	2	17	9								
20. Conductivity, Specific	845	880	800	800								
21. Copper (ug/l)	3	6	2	1								
22. Cyanide (mg/l)	.01	.00	.00	.01								
23. Discharge (CFS)												
24. Discharge, Instantaneous	.55	---	---	.49								
25. Dissolved Oxygen (mg/l)	5.5	8.8	8.3	8.0								
26. Fluoride (mg/l)	.3	.4	.3	.3								
27. Gallium (ug/l)												
28. Germanium (ug/l)												
29. Hardness (Ca, Mg) (mg/l)	340	380	350	340								
30. Hardness, Non-Carbonate (mg/l)	79	86	81	67								
31. Iron (ug/l)	20	40	10	0								
32. Kjeldahl Nitrogen (mg/l)	.37	2.7	.66	.31								
33. Lead (ug/l)	2	3	1	1								
34. Lithium (ug/l)	20	10	20	20								
35. Magnesium (mg/l)	49	46	47	44								
36. Manganese (ug/l)	5	20	0	5								
37. Mercury (ug/l)	.0	.0	.0	.0								
38. Molybdenum (ug/l)												
39. Nickel (ug/l)												
40. Nitrate (mg/l)	4.1	4.4	4.1	3.9								
41. Nitrite (mg/l)	.00	.00	.03	.03								
42. Nitrite Plus Nitrate (mg/l)	.92	1.0	.93	.89								
43. Nitrogen, Ammonia	.01	.00	.00	.00								
44. Odor (Severity)	0	0	0	0								
45. Oil & Grease (mg/l)	2	1	E2	3								
46. Ortho-Phosphate (mg/l)	.06	.09	.03	.03								
47. Ortho-Phosphorus (mg/l)	.02	.03	.01	.01								
48. Pesticides												
49. pH	8.5	---	9.0	8.8								
50. Phosphorus, Total (mg/l)	.12	.41	.03	.03								
51. Potassium (mg/l)	1.5	1.0	.7	.7								
52. Selenium (ug/l)	3	5	4	5								
53. Silica (mg/l)	23	21	22	23								
54. Silver (ug/l)												
55. Sodium (mg/l)	56	49	39	55								
56. Sodium Adsorption Ratio	1.3	1.1	.9	1.3								
57. Sodium (%)	27	22	20	26								
58. Solids, Dissolved (mg/l)	520	527	482	521								
59. Solids, Dissolved T/D	.77	---	---	.69								
60. Solids, Dissolved T/Ac-Ft	.71	.72	.66	.71								
61. Solids, Suspended												
62. Strontium (ug/l)												
63. Sulfate (mg/l)	170	150	140	160								
64. Sulfide (mg/l)	.0	.2	.2	.0								
65. Temperature (°C)	27.5	8.5	19.0	12.5								
66. Tin (ug/l)												
67. Titanium (ug/l)												
68. Turbidity JTU)	50	210	32	13								
69. Vanadium (ug/l)												
70. Zinc (ug/l)	0	10	10	0								
71. Zirconium (ug/l)												
72. Calcium (mg/l)												
73. Complete Element Span												
74. Radioactivity												
Gross Alpha (pci)												
Radium 226*												
Gross Beta												
Thorium 230**												
Uranium**												
75. Total Organic Carbon (mg/l)												
If TOC >10 mg/liter, then												
Nitrogen (Base Extraction)												
Organic Carbon, Dissolved												
Organic Carbon, Suspended												
Phenols												
Sulfur (Acid Extraction)												
76. Total Ortho-Phosphorous (mg/l)	.03	.04	.01	.01								
77. Phosphate	.37	1.3	.09	.09								

less than 1,100 umhos/cm during the first half of calendar year 1975. From June to mid-August to mid-September to a high of 1,640 umhos/cm. Mean conductivity then decreased to 1,040 umhos/cm by the end of September 1975. Boron values have remained relatively constant at about 0.1 mg/l during the 1975 water year at the Corral Gulch stream gaging station near the west line of Tract C-a. Flouride concentrations decreased from 0.3 mg/l in Junuary of 1975 to 0.2 mg/l in May of 1975. Flouride concentration then stabilized at 0.3 mg/l from late May to late September 1975. Plots of the data from the Corral Gulch stream gage near the west line of Tract C-a are presented in Progress Report 5 - Interpretive Text. Table 1.2-4 is a summary of the water analysis for that stream gaging station.

Daily mean discharge for the stream gaging station on Corral Gulch east of Tract C-a is shown on Figure 1.2-2. Increases in discharge at Corral Gulch east of Tract C-a in April, May and June 1975, were due to the RBOSP pumping tests and the intensified natural flow of snow melt runoff from Box Elder Gulch. By the end of September 1975 flow had decreased to 0.6 cfs. Conductivity for the stream gaging station located on Corral Gulch east of Tract C-a varied from 1,200 to 1,300 umhos/cm. The mean conductivity increased to around 2,000 umhos/cm near the end of May 1975 at which time the stream flow was at its highest as a result of spring runoff and the RBOSP pumping tests. The mean conductivity dropped back to a value of 1,200 umhos/cm by mid-June and remained relatively stable through September 1975. Figure 1.2-3, an example, is a plot of the mean continuous conductivity recorded at the Corral Gulch stream gaging station. Boron concentrations recorded at slightly over 0.1 mg/l from January to March 1975, increased to about 0.67 mg/l during maximum stream flow around the end of May 1975. Boron concentrations then decreased from June through September 1975 to between 0.1 mg/l and 0.17 mg/l. Flouride concentrations have fluctuated around 0.4 mg/l to 0.5 mg/l from January to September of 1975, with the exception of the period of time that pumping tests were being conducted at G-S D19 and G-S D18 (see Figure 1.2-2 for duration of those pumping tests). During the G-S D19 pumping tests flouride concentrations increased to over 4.0 mg/l at the stream gage but quickly declined after pumping tests had stopped. From mid-June to the end of September fluoride values stabilized averaging about 0.5 mg/l. Plots of data from the stream gaging station on Corral Gulch east of Tract C-a are presented in Progress Report 5 - Interpretive Text. A summary of the water quality analysis for that gaging station is presented in Table 1.2-5.

The instantaneous discharge data from the stream gaging station on Corral Gulch near the 84 Ranch indicates a flow in June and July fluctuating from about 0.8 cfs to 0.5 cfs. No flow was recorded during the month of August. Flow was measured in mid-September fluctuating from 0.3 cfs to 0.4 cfs. Instantaneous conductivity data indicated a fluctuation of conductivity around and slightly less than 2,000 umhos/cm during the June and July 1975 flow. Flow in September 1975 fluctuated from about 1,800 umhos/cm to 980 umhos/cm. No trend is as yet evident from the instantaneous data collected

TABLE 1.2-4
SUMMARY WATER ANALYSIS RBOSP
STREAM GAGING STATION, USGS 0930235
CORRAL GULCH NEAR WEST LINE TRACT C-a

		3/12/75	3/16/75	4/9/7	4/23/75	5/14/7	5/28/75	6/11/75	6/24/7	7/15/75	7/30/75	8/12/75	8/26/75
1.	Alkalinity (mg/l)			324	301	291	322	318	305	312	315	349	335
2.	Aluminum (ug/l)			---	---	---	---	---	---	---			
3.	Ammonia (mg/l)			.12	.00	.04	.00	.00	.05	.04	.00	.00	.00
4.	Aromatics, Polycyclic			---		---							
5.	Arsenic (ug/l)			4	5	4	9	4	4	4	4	4	4
6.	Barium (ug/l)			<100	0	100	0	100	0	200	0	100	200
7.	Beryllium (ug/l)			---		---							
8.	Bicarbonate (mg/l)			395	367	355	393	388	372	380	384	425	408
9.	Bismuth (ug/l)			---		---							
10.	Boron (ug/l)			90	100	90	90	90	100	80	110	90	100
11.	Cadmium (ug/l)			0	1	0	0	0	0	0	1	0	0
12.	Carbonate (mg/l)			0	0	0	0	0	0	0	0	0	0
13.	Carbon Dioxide (mg/l)			2.0	2.3	11	32	4.9	1.2	2.4	3.1	2.2	5.2
14.	Chloride (mg/l)			7.8	9.2	8.9	6.8	5.9	7.0	8.3	6.9	8.2	7.6
15.	Chromium (ug/l)			0	0	0	0	0	0	0	0	0	10
16.	Cobalt (ug/l)												
17.	COD												
18.	Coliform, Total & Fecal												
19.	Color (PVC)			9	3	10	7	8	8	15			
20.	Conductivity, Specific			1080	1100	1100	900	1050	1100	1200	1125	925	1150
21.	Copper (ug/l)			8	3	2	1	-	4	0	2	4	1
22.	Cyanide (mg/l)			.00	.01	.01	.00	.00	.01	.00	.00	.00	.00
23.	Discharge (CFS)												
24.	Discharge, Instantaneous			.04	.03	.02	.10	---	.18	.10	.24	.47	.49
25.	Dissolved Oxygen (mg/l)			---	7.0	8.7	9.1	5.6	6.4	7.0	9.2	---	---
26.	Fluoride (mg/l)			.2	.2	.2	.2	.3	.3	.3	.3	.2	.3
27.	Gallium (ug/l)												
28.	Germanium (ug/l)												
29.	Hardness (Ca, Mg) (mg/l)			460	430	420	460	560	450	460	480	460	470
30.	Hardness, Non-Carbonate (mg/l)			140	130	130	140	140	140	150	160	110	130
31.	Iron (ug/l)			50	20	20	80	30	10	30	10	20	50
32.	Kjeldahl Nitrogen (mg/l)			4.2	.36	.30	1.0	.89	.25	.65	1.0	.47	.52
33.	Lead (ug/l)			0	3	1	2	0	2	0	0	1	0
34.	Lithium (ug/l)			20	10	20	20	10	20	10	20	20	20
35.	Magnesium (mg/l)			60	59	56	58	61	60	60	66	58	60
36.	Manganese (ug/l)			0	0	0	20	0	0	0	10	0	10
37.	Mercury (ug/l)			1.0	.0	.00	.0	.0	.0	.0	.0	.0	.0
38.	Molybdenum (ug/l)			---		---							
39.	Nickel (ug/l)			---		---							
40.	Nitrate (mg/l)			4.3	2.8	2.2	4.4	6.6	5.3	4.0	3.7	3.6	4.0
41.	Nitrite (mg/l)			.00	.03	.00	.00	.03	.00	.03	.03	.03	.03
42.	Nitrite Plus Nitrate (mg/l)			.98	.64	.50	1.0	1.5	1.2	.91	.85	.83	.92
43.	Nitrogen, Ammonia			.09		.03					.00	.00	.00
44.	Odor (Severity)			1	0	0	0	0	0	0	0	---	---
45.	Oil & Grease (mg/l)			3	---	0	2	1	3	4	1	1	0
46.	Ortho-Phosphate (mg/l)			.06	.06	.06	.06	.00	.03	.06			
47.	Ortho-Phosphorus (mg/l)			.02	.02	.02	.02	.00	.01	.02	.01	.00	.00
48.	Pesticides												
49.	pH			8.5	8.4	7.7	7.3	8.1	8.7	8.4	8.3	8.5	8.1
50.	Phosphorus, Total (mg/l)			1.3	.06	.03	.07	.20	.01	.03	.06	.07	.02
51.	Potassium (mg/l)			1.6	1.5	1.5	1.4	1.1	1.0	1.5	1.5	1.6	1.3
52.	Selenium (ug/l)			4	4	4	5	3	5	4	4	5	3
53.	Silica (mg/l)			19	20	18	19	23	22	21	23	22	22
54.	Silver (ug/l)			---		---							
55.	Sodium (mg/l)			86	90	91	75	49	80	87	87	84	86
56.	Sodium Adsorption Ratio			1.7	1.9	1.9	1.5	1.0	1.6	1.8	1.7	1.7	1.7
57.	Sodium ( )			29	31	32	26	19	28	29	28	29	28
58.	Solids, Dissolved (mg/l)			729	719	719	709	663	699	734	760	755	752
59.	Solids, Dissolved T/D			.08	.06	.04	.19	---	.34	.20	.49	.96	.99
60.	Solids, Dissolved T/Ac-Ft			.99	.98	.98	.96	90	.95	1.00	1.03	1.03	1.02
61.	Solids, Suspended												
62.	Strontium (ug/l)			---		---							
63.	Sulfate (mg/l)			2.70	280	2.90	260	240	260	280	300	280	280
64.	Sulfide (mg/l)			.2	.0	.0	.0	.1	.0	.0	.0	.2	.2
65.	Temperature (°C)			2.0	21.0	20.0	9.0	19.0	18.0	22.0	26.5	21.0	22.5
66.	Tin (ug/l)			---		---							
67.	Titanium (ug/l)			---		---							
68.	Turbidity JTU)			450	15	18	75	120	13	17	34	36	33
69.	Vanadium (ug/l)			---		---							
70.	Zinc (ug/l)			20	0	10	0	10	6	0	20	10	10
71.	Zirconium (ug/l)			---		---							
72.	Calcium (mg/l)			85		76					82	87	89
73.	Complete Element Span												
74.	Radioactivity												
	Gross Alpha (pci)												
	Radium 226*												
	Gross Beta												
	Thorium 230**												
	Uranium**												
75.	Total Organic Carbon (mg/l)			---		---							
	If TOC 10 mg/liter, then												
	Nitrogen (Base Extraction)												
	Organic Carbon, Dissolved												
	Organic Carbon, Suspended												
	Phenols												
	Sulfur (Acid Extraction)												
76.	Total Ortho-Phosphorous (mg/l)			.45	.01	.06	[illegible]	[illegible]	[illegible]	[illegible]	.02	.03	.00
77.	Phosphate			---	.18	09	.21	.61	.03	.09			

TABLE 1.2-4
(CONTINUED)
SUMMARY WATER ANALYSIS
STREAM GAGING STATION, USGS 0930235
CORRAL GULCH NEAR WEST LINE TRACT C-a

	9/8/75	9/24/75										
1. Alkalinity (mg/l)	341	334										
2. Aluminum (ug/l)	40											
3. Ammonia (mg/l)	.00	.01										
4. Aromatics, Polycyclic												
5. Arsenic (ug/l)	6	4										
6. Barium (ug/l)	<200	<200										
7. Beryllium (ug/l)	<1	<1										
8. Bicarbonate (mg/l)	416	407										
9. Bismuth (ug/l)	<5											
10. Boron (ug/l)	100	100										
11. Cadmium (ug/l)	2	0										
12. Carbonate (mg/l)	0	0										
13. Carbon Dioxide (mg/l)	4.2	3.3										
14. Chloride (mg/l)	7.5	7.3										
15. Chromium (ug/l)	0	10										
16. Cobalt (ug/l)	<3											
17. COD	16											
18. Coliform, Total & Fecal												
19. Color (PCU)												
20. Conductivity, Specific	1050	1100										
21. Copper (ug/l)	5	1										
22. Cyanide (mg/l)	.00	.00										
23. Discharge (CFS)												
24. Discharge, Instantaneous	.27	.44										
25. Dissolved Oxygen (mg/l)	9.0	9.8										
26. Fluoride (mg/l)	.3	.3										
27. Gallium (ug/l)	<3											
28. Germanium (ug/l)	<5											
29. Hardness (Ca, Mg) (mg/l)	470	480										
30. Hardness, Non-Carbonate (mg/l)	130	150										
31. Iron (ug/l)	0	40										
32. Kjeldahl Nitrogen (mg/l)	.43	.64										
33. Lead (ug/l)	4	1										
34. Lithium (ug/l)	20	20										
35. Magnesium (mg/l)	60	61										
36. Manganese (ug/l)	0	10										
37. Mercury (ug/l)	.0	.0										
38. Molybdenum (ug/l)	46											
39. Nickel (ug/l)	<5											
40. Nitrate (mg/l)	3.8	3.4										
41. Nitrite (mg/l)	.03	.03										
42. Nitrite Plus Nitrate (mg/l)	.86	.78										
43. Nitrogen, Ammonia	.00	.01										
44. Odor (Severity)	0	0										
45. Oil & Grease (mg/l)	1	0										
46. Ortho-Phosphate (mg/l)												
47. Ortho-Phosphorus (mg/l)	.00	.01										
48. Pesticides												
49. pH	8.2	8.3										
50. Phosphorus, Total (mg/l)	.07	.06										
51. Potassium (mg/l)	1.2	1.1										
52. Selenium (ug/l)	3	3										
53. Silica (mg/l)	21	21										
54. Silver (ug/l)	0											
55. Sodium (mg/l)	86	89										
56. Sodium Adsorption Ratio	1.7	1.8										
57. Sodium ( )	28	29										
58. Solids, Dissolved (mg/l)	756	767										
59. Solids, Dissolved T/D	.55	.91										
60. Solids, Dissolved T/Ac-Ft	1.03	1.04										
61. Solids, Suspended												
62. Strontium (ug/l)	1400											
63. Sulfate (mg/l)	280	290										
64. Sulfide (mg/l)	.3	.0										
65. Temperature (°C)	12.0	13.5										
66. Tin (ug/l)	<5											
67. Titanium (ug/l)	<3											
68. Turbidity JTU)	2	20										
69. Vanadium (ug/l)	<3.0											
70 Zinc (ug/l)	10	10										
71. Zirconium (ug/l)												
72. Calcium (mg/l)	90	93										
73 Complete Element Span												
74 Radioactivity												
Gross Alpha (pci)	<8.9											
Radium 226*												
Gross Beta												
Thorium 230**												
Uranium**												
75 Total Organic Carbon (mg/l)	8.0											
If TOC 10 mg/liter, then												
Nitrogen (Base Extraction)												
Organic Carbon, Dissolved												
Organic Carbon, Suspended												
Phenols												
Sulfur (Acid Extraction)												
76 Total Ortho-Phosphorous (mg/l)	.01	.01										
77. Phosphate												
78. Phosphorus, Dissolved												

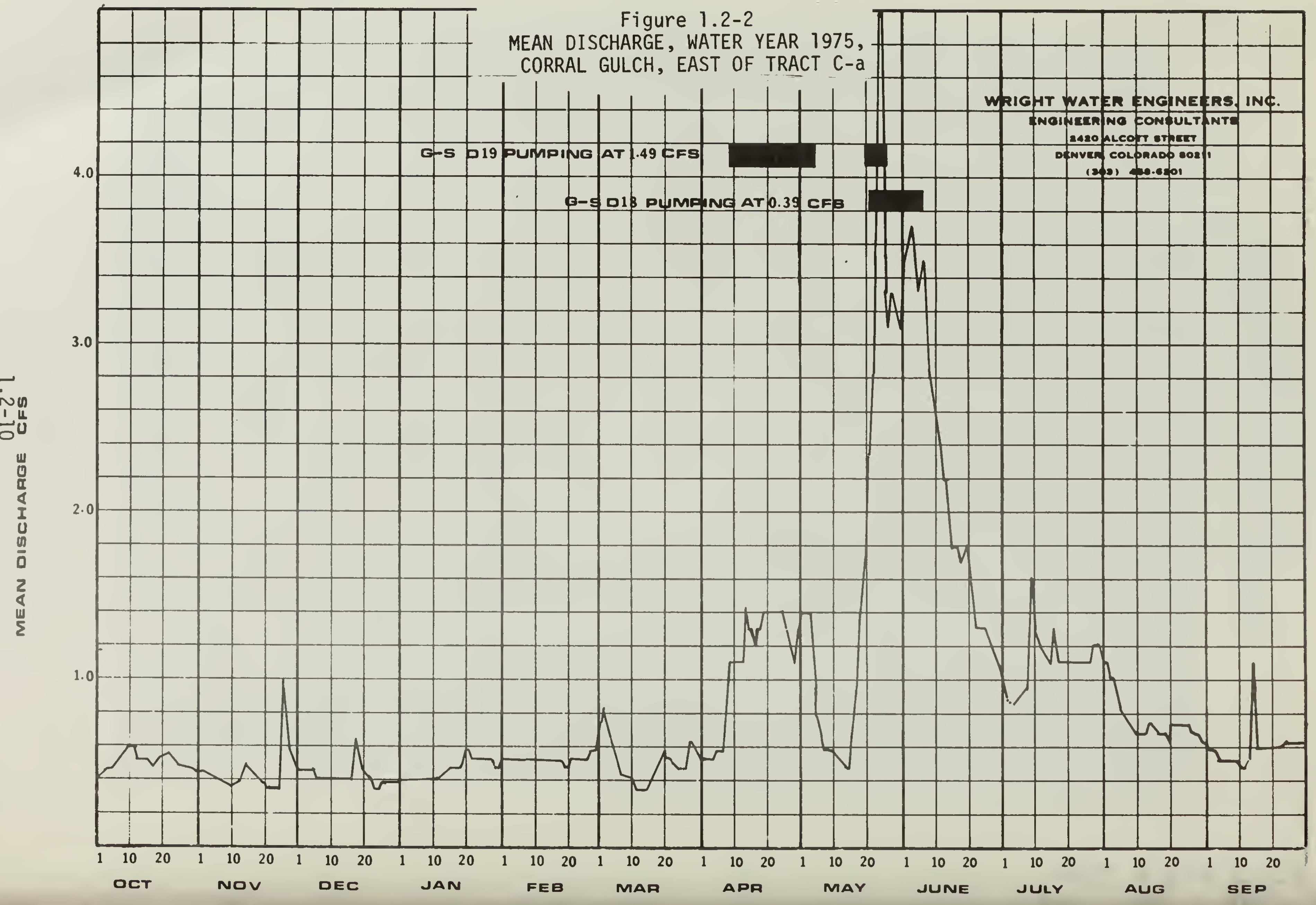


Figure 1.2-2
MEAN DISCHARGE, WATER YEAR 1975, CORRAL GULCH, EAST OF TRACT C-a

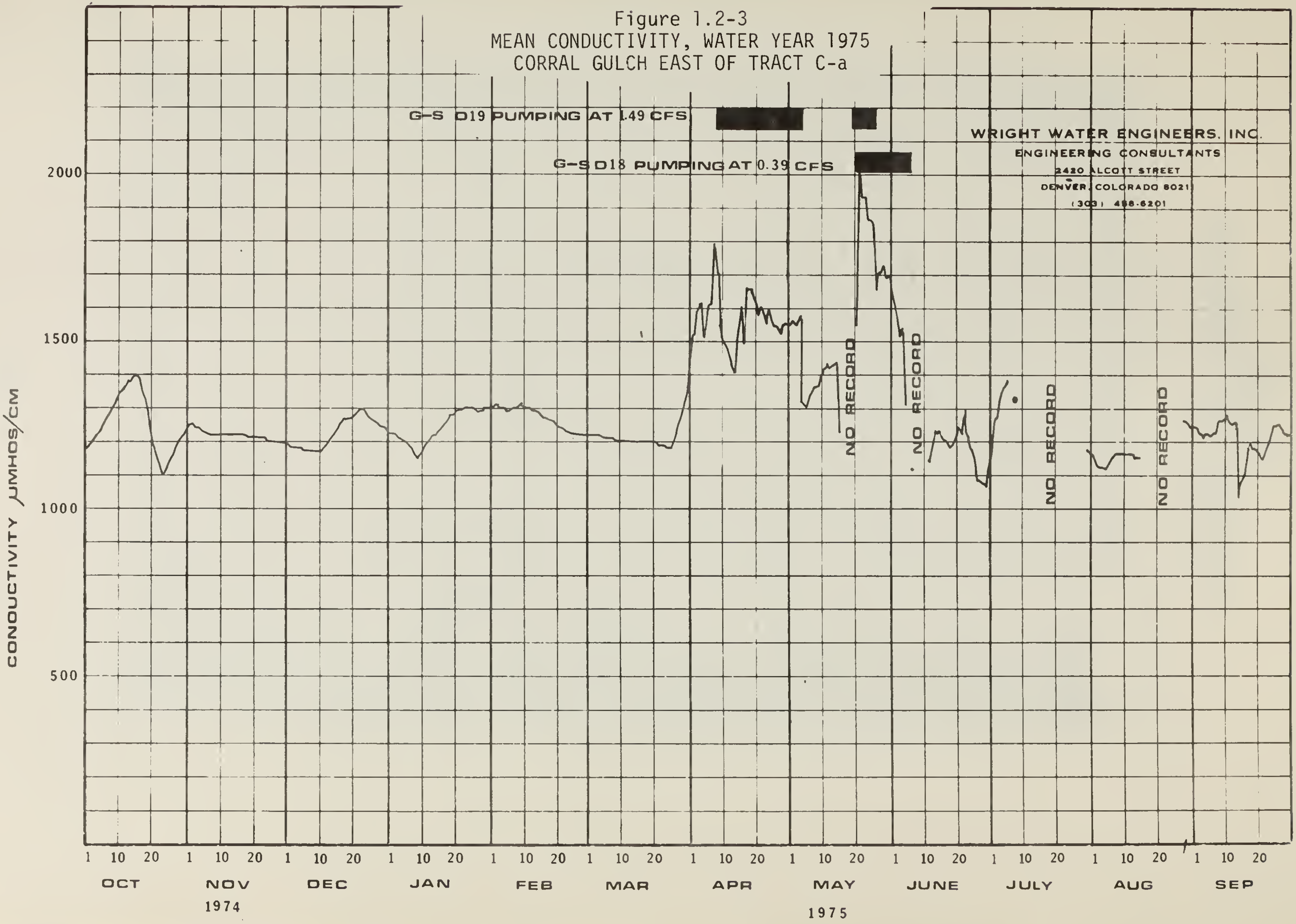


Figure 1.2-3
MEAN CONDUCTIVITY, WATER YEAR 1975
CORRAL GULCH EAST OF TRACT C-a

TABLE 1.2-5
SUMMARY WATER ANALYSIS
STREAM GAGING STATION, USGS 09306242
CORRAL GULCH EAST OF TRACT C-a

Date Time	3/12/75 1100	3/26/75 1415	4/9/75 1045	4/9/75 1100	4/23/75 1100	5/14/75 1245	5/28/75 1430	6/11/75 1545	6/24/75 1450	7/15/75 1230	7/30/75 1110	8/12/75 1500
1. Alkalinity (mg/l)	417	---	---	739	603	421	668	378	401	389	381	349
2. Aluminum (ug/l)	20	---	---	---	---	---	---	---	---	---	---	
3. Ammonia (mg/l)	.28	---	---	.35	.15	.03	.22	.00	00	04	00	00
4. Aromatics, Polycyclic												
5. Arsenic (ug/l)	6	---	---	7	2	5	9	4	3	5	6	6
6. Barium (ug/l)	50	---	---	100	0	0	100	100	0	100	0	100
7. Beryllium (ug/l)	<2	---	---	---	---	---	---	---	---	-		
8. Bicarbonate (mg/l)	508	---	---	901	735	513	815	461	489	474	464	476
9. Bismuth (ug/l)	<5	---	---	---	---	---	---	---	---	---		
10. Boron (ug/l)	100	---	---	320	550	160	670	150	160	140	120	140
11. Cadmium (ug/l)	<60	---	---	0	1	1	0	0	0	0	3	0
12. Carbonate (mg/l)	0	---	---	0	0	0	0	0	0	0	0	0
13. Carbon Dioxide (mg/l)	13	---	---	7.2	7.4	65	13	7.4	4.9	4.8	[illegible]	4.3
14. Chloride (mg/l)	8.9	---	---	11	16	11	15	8.8	9.7	11	10	11
15. Chromium (ug/l)	<5	---	---	0	0	0	0	0	0	0	0	10
16. Cobalt (ug/l)	<5	---	---	---	---	---	---	---				
17. COD	94	---	---	---	---	---	---					
18. Coliform, Total & Fecal												
19. Color (PVC)	8	---	---	5	0	5	6	17	19	6	6	
20. Conductivity, Specific	1200	---	---	1725	1550	1300	1550	1100	1200	1000	1150	1200
21. Copper (ug/l)	2	---	---	3	6	1	1	0	1	0	4	3
22. Cyanide (mg/l)	.00	---	---	.00	.01	.01	02	02	.01	00	00	00
23. Discharge (CFS)												
24. Discharge, Instantaneous	.34	---	---	1.1	1.3	.46	3.1	---	1.5	1.1	1.0	[illegible]
25. Dissolved Oxygen (mg/l)	9.0	---	5.4	5.4	7.3	8.0	8.1	5.0	4.8	6.7	7.6	
26. Fluoride (mg/l)	.4	---	---	10	4.3	.4	2.8	5	5	5	[illegible]	4
27. Gallium (ug/l)	<2	---	---	---	---	---	---	--				
28. Germanium (ug/l)	<6	---	---	---	---	---	---	-	---			
29. Hardness (Ca, Mg) (mg/l)	520	---	---	360	380	480	390	420	410	430	460	430
30. Hardness, Non-Carbonate (mg/l)	98	---	---	0	0	58	0	42	6	37	75	83
31. Iron (ug/l)	120	---	---	30	10	30	30	70	0	20	10	20
32. Kjeldahl Nitrogen (mg/l)	.67	---	---	2.4	1.1	14	2.2	67	30	52	30	19
33. Lead (ug/l)	<6	---	---	2	8	1	1	0	1	0	3	0
34. Lithium (ug/l)	14	---	---	30	20	10	20	10	10	0	10	10
35. Magnesium (mg/l)	70	---	---	52	59	63	53	56	54	55	64	57
36. Manganese (ug/l)	43	---	---	0	70	20	6	0	5	0	0	10
37. Mercury (ug/l)	.0	---	---	.3	0	0	0	.0	0	0	0	0
38. Molybdenum (ug/l)	30	---	---	---	---		---	--				
39. Nickel (ug/l)	<4	---	---	---	---	--	---	---		-		
40. Nitrate (mg/l)	1.2	---	---	1.2	1.5	1.4	3.0	3.0	2.5	1.6	1.5	1.3
41. Nitrite (mg/l)	.07	---	---	.00	.10	.00	03	0.3	03	03	03	03
42. Nitrite Plus Nitrate (mg/l)	.28	---	---	.28	36	32	.68	.69	57	37	34	30
43. Nitrogen, Ammonia	.22	---	---	.27	12	02	17	.00	00	.05	00	00
44. Odor (Severity)	3	2	2	---	0	0	1	0	0	0	1	
45. Oil & Grease (mg/l)	4	---	---	2	3	0	2	2	3	2	1	1
46. Ortho-Phosphate (mg/l)	.28	---	---	.06	.12	.15	.12	.00	06	.15	03	
47. Ortho-Phosphorus (mg/l)	.09	--	---	.02	.04	05	.04	.00	02	.05	01	02
48. Pesticides												
49. pH	7.8	---	---	8.3	8.2	7.1	8.0	8.0	8.2	[illegible]	[illegible]	[illegible]
50. Phosphorus, Total (mg/l)	.37	---	---	.60	.58	.05	.41	.54	07	04	04	04
51. Potassium (mg/l)	1.4	---	---	2.3	2.0	1.8	[illegible]	1.4	1.4	1.4	[illegible]	1.4
52. Selenium (ug/l)	2	---	---	2	1	2	2	3	4	3	3	4
53. Silica (mg/l)	13	---	---	19	19	21	20	23	21	21	22	22
54. Silver (ug/l)	0	-	--	---	---	---		--	---	- -	-	
55. Sodium (mg/l)	110	---	---	300	240	120	250	94	110	110	110	120
56. Sodium Adsorption Ratio	2.1	---	---	6.8	5.4	2.4	5.5	2.0	2.4	[illegible]	[illegible]	2.5
57. Sodium ( )	37	-	---	64	58	35	58	33	37	36	[illegible]	38
58. Solids, Dissolved (mg/l)	838	---	---	1140	1040	850	1020	691	724	775	[illegible]	793
59. Solids, Dissolved T/D	.77	---	---	3.57	3.73	1.06	8.54	---	2.97	2.34	[illegible]	1.33
60. Solids, Dissolved T/Ac-Ft	1.14	---	---	1.55	1.41	1.16	1.39	[illegible]	[illegible]	1.05	1.06	[illegible]
61. Solids, Suspended												
62. Strontium (ug/l)	1600	--	- -	---	--	---	--	---	---	-	-	
63. Sulfate (mg/l)	290	---	---	240	280	290	200	200	210	260	260	290
64. Sulfide (mg/l)	.0	---	---	.3	.0	2	[illegible]	.2	.0	0	0	2
65. Temperature (°C)	8.0	---	---	7.0	13.0	14.0	11.0	19.0	15.0	15.0	17.0	13.0
66. Tin (ug/l)	<5		-		---	---		---	-	--	-	
67. Titanium (ug/l)	<4		--	-	- -	---						
68. Turbidity (JTU)	1000	--	---	740	50	1	120	150	50	13	4	7
69. Vanadium (ug/l)	3.0	-	--	--	-			---	-	-	-	
70. Zinc (ug/l)	0	---	---	40	10	6	10	10	[illegible]	0	[illegible]	0
71. Zirconium (ug/l)	<9		-	---	---	---						
72. Calcium (mg/l)	90	-	---	60	55	[illegible]	[illegible]					70
73. Complete Element Span												
74. Radioactivity												
Gross Alpha (pci)	<[illegible]											
Radium 226*												
Gross Beta	<2.4											
Thorium 230**												
Uranium**												
75. Total Organic Carbon (mg/l)	9.8	-	--	--								
If TOC 10 mg/liter, then												
Nitrogen (Base Extraction)												
Organic Carbon, Dissolved												
Organic Carbon, Suspended												
Phenols												
Sulfur (Acid Extraction)												
76. Total Ortho-Phosphorous	11	-	..	5	05	06	04	[illegible]	[illegible]	[illegible]	[illegible]	04
77. Phosphate					[illegible]	15	1.3	1	[illegible]	[illegible]	[illegible]	

TABLE 1.2-5
(CONTINUED)
SUMMARY WATER ANALYSIS
STREAM GAGING STATION, USGS 09306242
CORRAL GULCH EAST OF TRACT C-a

		8/27/75 1130	9/8/75 1430	9/24/75 1225
1.	Alkalinity (mg/l)	413	406	420
2.	Aluminum (ug/l)		30	
3.	Ammonia (mg/l)	.00	.00	.03
4.	Aromatics, Polycyclic			
5.	Arsenic (ug/l)	4	7	6
6.	Barium (ug/l)	<200	<200	<200
7.	Beryllium (ug/l)		<2	
8.	Bicarbonate (mg/l)	503	495	512
9.	Bismuth (ug/l)		<6	
10.	Boron (ug/l)	150	150	160
11.	Cadmium (ug/l)	0	0	0
12.	Carbonate (mg/l)	0	0	0
13.	Carbon Dioxide (mg/l)	16	13	21
14.	Chloride (mg/l)	9.7	11	10
15.	Chromium (ug/l)	50	0	10
16.	Cobalt (ug/l)		3	
17.	COD			
18.	Coliform, Total & Fecal			
19.	Color (PCU)			
20.	Conductivity, Specific	1100	1200	1300
21.	Copper (ug/l)	1	2	1
22.	Cyanide (mg/l)	.00	.00	.00
23.	Discharge (CFS)			
24	Discharge, Instantaneous	.66	.57	.34
25.	Dissolved Oxygen (mg/l)	---	9.0	10.3
26	Fluoride (mg/l)	.5	.5	.5
27.	Gallium (ug/l)		<3	
28.	Germanium (ug/l)		<6	
29.	Hardness (Ca, Mg) (mg/l)	490	470	490
30.	Hardness, Non-Carbonate (mg/l)	73	64	74
31.	Iron (ug/l)	10	50	10
32.	Kjeldahl Nitrogen (mg/l)	.30	.25	.48
33.	Lead (ug/l)	0	2	3
34	Lithium (ug/l)	10	10	10
35.	Magnesium (mg/l)	67	65	66
36.	Manganese (ug/l)	10	10	20
37.	Mercury (ug/l)	.0	.0	.0
38.	Molybdenum (ug/l)		56	
39.	Nickel (ug/l)		6	
40.	Nitrate (mg/l)	1.2	1.2	1.2
41.	Nitrite (mg/l)	.03	.03	.03
42.	Nitrite Plus Nitrate (mg/l)	.29	.27	.29
43	Nitrogen, Ammonia	.00	.00	.03
44	Odor (Severity)		0	0
45	Oil & Grease (mg/l)	1	1	2
46	Ortho-Phosphate (mg/l)			
47	Ortho-Phosphorus (mg/l)	.02	.02	.03
48	Pesticides			
49	pH	7.7	7.8	7.6
50	Phosphorus, Total (mg/l)	.00	.04	.07
51.	Potassium (mg/l)	1.7	1.5	1.3
52.	Selenium (ug/l)	1	2	3
53.	Silica (mg/l)	21	21	21
54.	Silver (ug/l)		0	
55	Sodium (mg/l)	120	120	120
56.	Sodium Adsorption Ratio	2.4	2.4	2.4
57	Sodium ( )	35	36	35
58.	Solids, Dissolved (mg/l)	834	836	852
59.	Solids, Dissolved T/D	1.49	1.29	.78
60	Solids, Dissolved T/Ac-Ft	1.13	1.14	1.16
61	Solids, Suspended			
62	Strontium (ug/l)		1400	
63	Sulfate (mg/l)	280	290	290
64	Sulfide (mg/l)	.0	.2	.0
65	Temperature (°C)	15.5	11.0	12.0
66	Tin (ug/l)		6	
67	Titanium (ug/l)		3	
68	Turbidity JTU	2	0	2
69	Vanadium (ug/l)		4.0	
70	Zinc (ug/l)	0	0	10
71	Zirconium (ug/l)			
72	Calcium (mg/l)	84	81	89
73	Complete Element Span			
74	Radioactivity			
	Gross Alpha (pCi)		6.7	
	Radium 226*			
	Gross Beta		9.4	
	Thorium 230**			
	Uranium**			
75	Total Organic Carbon (mg/l)			
	If TOC 10 mg/liter, then			
	Nitrogen (Base Extraction)			
	Organic Carbon, Dissolved			
	Organic Carbon, Suspended			
	Phenols			
	Sulfur (Acid Extraction)			
76	Total Ortho-Phosphorous (mg/l)	.02	.04	.03
77	Phosphate			
78	Phosphorus, Dissolved			

from the new stream gaging station. Boron values were stable averaging about 0.2 mg/l. Flouride also has remained stable averaging about 0.3 mg/l. Summary of the water quality analysis from the stream gaging station on Corral Gulch near 84 Ranch is presented in Table 1.2-6. Data plots for that stream gaging station are presented in Progress Report 5 - Interpretive Text.

Continuous mean discharge data for the stream gaging station on Yellow Creek near White River showed a mean peak discharge of 3.0 cfs in March 1975. The peak declined to a minimum flow which held steady at 0.7 cfs during late August and September of 1975. The mean continuous conductivity varied from 3,000 to 4,000 umhos/cm from January to April 1975. From April to mid-July 1975 the mean conductivity increased to nearly 5,000 umhos/cm. Following the mean high in mid-July 1975, the conductivity declined and instantaneous data collected in early October 1975, indicated the conductivity to be around 4,000 umhos/cm. Boron concentrations have fluctuated from between 0.69 mg/l and 0.79 mg/l from September through October 12, 1975. These values are about the same as the average for the rest of the 1975 water year. Flouride concentrations varied widely since January 1975, from about 1.6 mg/l to 2.5 mg/l decreased from a high of 2.5 mg/l in August 1975, to about 2.0 mg/l near mid-October 1975. Plots of the data from the Yellow Creek stream gaging station near White River are presented in the Interpretive Text portion of Progress Report 5. Table 1.2-7 is a summary of the water quality analysis of samples from that stream gaging station.

Progress Report 4 described the storage type and recording type rain gages. The rainfall intensity gage which accompanies the recording type rain gage records the time of each rainfall event and measures precipitation depth with respect to a time increment of 5 minutes. The rainfall intensity data were received for the first time from the WRD of the USGS during this quarterly reporting period.

Information from the storage type rain gaging stations indicate increases in precipitation during August, October, and November. Total precipitation during the period from August through November at Dry Fork, Box Elder Gulch, and Corral Gulch stations near the west line of Tract C-a were 3.1", 2.8" and 3.9" respectively. Figure 1.2-4 is an example plot of the storage type precipitation data.

Recording rain gages indicate that during the period from August through November, widespread precipitation which averaged 0.69 inches per month, occurred in late October 1975. Other precipitation events which were recorded over the same period were not correlatable between stations indicating that they occurred as localized rain showers. Cumulative totals recorded at stations near Cathedral Bluffs, Stake Springs Draw near Confluence with Corral Gulch, and Yellow Creek near White River from August through November are 5.26 inches, 2.16 inches, and 2.75 inches, respectively. Figure 1.2-5 is a sample of such data plot.

TABLE 1.2-6
SUMMARY WATER ANALYSIS
STREAM GAGING STATION, USGS 09306244
CORRAL GULCH NEAR 84 RANCH

	6/12/75 1300	6/25/75 1300	7/15/75 1330	7/30/75 1430	9/9/75 0930	9/24/75 1345						
1. Alkalinity (mg/l)	532	477	523	525	540	479						
2. Aluminum (ug/l)	50				20							
3. Ammonia (mg/l)	.01	.00	.00	.05	.00	.06						
4. Aromatics, Polycyclic												
5. Arsenic (ug/l)	3	3	5	6	7	4						
6. Barium (ug/l)	0	0	200	0	<200	100						
7. Beryllium (ug/l)	<4				<2							
8. Bicarbonate (mg/l)	649	582	638	640	658	584						
9. Bismuth (ug/l)	<9				<9							
10. Boron (ug/l)	190	160	190	150	210	190						
11. Cadmium (ug/l)	0	0	1	1	0	1						
12. Carbonate (mg/l)	0	0	0	0	0	0						
13. Carbon Dioxide (mg/l)	3.3	2.3	4.1	3.2	8.4	7.4						
14. Chloride (mg/l)	19	21	23	21	19	19						
15. Chromium (ug/l)	10	0	10	0	0	10						
16. Cobalt (ug/l)	<9				< 4							
17. COD												
18. Coliform, Total & Fecal												
19. Color (PCU)												
20. Conductivity, Specific	2000	1780	2000	1900	1800	980						
21. Copper (ug/l)	0	1	1	2	3	2						
22. Cyanide (mg/l)	.00	.01	.00	.00	.00	.00						
23. Discharge (CFS)												
24. Discharge, Instantaneous	---	.81	.50	.72	.27	.43						
25. Dissolved Oxygen (mg/l)	4.4	10.4	7.6	13.8	10.2	7.9						
26. Fluoride (mg/l)	.3	.3	.3	.4	.3	.3						
27. Gallium (ug/l)	<4				<4							
28. Germanium (ug/l)	13				<9							
29. Hardness (Ca, Mg) (mg/l)	750	790	760	790	790	650						
30. Hardness, Non-Carbonate (mg/l)	220	320	240	270	250	170						
31. Iron (ug/l)	80	120	40	60	0	10						
32. Kjeldahl Nitrogen (mg/l)	.42	.43	.79	.86	.41	1.6						
33. Lead (ug/l)	0	1	8	0	1	3						
34. Lithium (ug/l)	10	20	0	0	0	10						
35. Magnesium (mg/l)	110	120	100	120	120	91						
36. Manganese (ug/l)	80	10	250	190	110	120						
37. Mercury (ug/l)	.0	.1	.0	.0	.0	.1						
38. Molybdenum (ug/l)	60				55							
39. Nickel (ug/l)	<9				<9							
40. Nitrate (mg/l)	.22	5.7	2.2	3.9	2.8	3.2						
41. Nitrite (mg/l)	.00	.07	.13	.16	.13	.10						
42. Nitrite Plus Nitrate (mg/l)	.05	1.3	.54	.94	.68	.78						
43. Nitrogen, Ammonia	.01	.00	.00	.04	.00	.05						
44. Odor (Severity)	0	0	0	0	0	0						
45. Oil & Grease (mg/l)	0	2	4	1	2	1						
46. Ortho-Phosphate (mg/l)												
47. Ortho-Phosphorus (mg/l)												
48. Pesticides												
49. pH	7.5	8.6	8.4	8.5	8.1	8.1						
50. Phosphorus, Total (mg/l)	.01	.36	.04	.02	.02	.00						
51. Potassium (mg/l)	1.9	2.4	4.4	4.1	2.8	2.8						
52. Selenium (ug/l)	1	6	3	3	2	3						
53. Silica (mg/l)	19	15	21	17	20	17						
54. Silver (ug/l)	<1				<1							
55. Sodium (mg/l)	190	170	180	190	180	170						
56. Sodium Adsorption Ratio	3.0	2.6	2.8	2.9	2.8	2.9						
57. Sodium ( )	35	32	34	34	33	36						
58. Solids, Dissolved (mg/l)	1370	1320	1390	1370	1360	1210						
59. Solids, Dissolved T/D	---	2.89	1.88	2.66	.99	1.40						
60. Solids, Dissolved T/Ac-Ft	1.86	1.80	1.89	1.86	1.85	1.65						
61. Solids, Suspended												
62. Strontium (ug/l)	2500				2300							
63. Sulfate (mg/l)	590	580	600	580	570	510						
64. Sulfide (mg/l)	.0	.0	.1	.0	.0	.0						
65. Temperature (°C)	10.0	13.0	20.0	23.0	12.0	20.5						
66. Tin (ug/l)	<9				<9							
67. Titanium (ug/l)	<5				4							
68. Turbidity (JTU)	2	20	6	5	0	1						
69. Vanadium (ug/l)	<9.0				<4.0							
70. Zinc (ug/l)	10	10	10	20	10	10						
71. Zirconium (ug/l)												
72. Calcium (mg/l)	120	120	140	120	120	110						
73. Complete Element Spar												
74. Radioactivity												
Gross Alpha (pCi												
Radium 226*												
Gross Beta												
Thorium 230**												
Uranium**												
75. Total Organic Carbon	11											
If TOC 10 mg/liter, [illegible]												
Nitrogen (Base Extra[illegible]												
Organic Carbon, Dissolved												
Organic Carbon, Suspended												
Phenols												
Sulfur (Acid Extract[illegible]												
76. Total Ortho-Phosphorus	.01	.00	.01	.01	.01	.01						
77. Phosphate												
78. Phosphorus, Dissolved	.01	.00	.02	.00	.01	.01						

TABLE 1.2-7
SUMMARY WATER ANALYSIS
STREAM GAGING STATION, USGS 09306255
YELLOW CREEK NEAR WHITE RIVER

Date Time	3/12/75 1400	3/26/75 1030	4/9/75 1200	4/9/75 1300	4/23/75 1000	5/15/75 1100	5/28/75 1115	6/13/75 1115	6/26/75 1330	7/16/75 1045	7/28/75 0920	8/14/75 0915
1. Alkalinity (mg/l)	1330	1330	1380	1580	1220	1380	1270	1460	1500	1280	1580	1510
2. Aluminum (ug/l)	150	---	---	---	---	---						
3. Ammonia (mg/l)	.00	.22	.24	.30	.00	.08	.00	.01	.03	.00	.05	.00
4. Aromatics, Polycyclic												
5. Arsenic (ug/l)	5	3	1	5	6	5	5	5	9	6	4	6
6. Barium (ug/l)	200	100	<100	300	0	300	200	300	200	400	0	400
7. Beryllium (ug/l)	<4	---	---	---	---	---						
8. Bicarbonate (mg/l)	1620	1210	1480	930	1490	1510	1150	1490	1550	1340	596	1220
9. Bismuth (ug/l)	<15	---	---	---	---	---						
10. Boron (ug/l)	560	630	680	700	630	640	640	730	740	670	690	720
11. Cadmium (ug/l)	<170	0	0	0	1	2	1	0	0	1	1	0
12. Carbonate (mg/l)	0	203	97	0	1	87	194	140	139	107	657	308
13. Carbon Dioxide (mg/l)	10	5.2	4.3	6.2	3.8	5.4	---	1.1	2.3	7.9	3.9	12
14. Chloride (mg/l)	130	110	130	130	120	120	100	130	130	110	140	140
15. Chromium (ug/l)	<15	0	0	0	0	0	0	0	0	0	0	0
16. Cobalt (ug/l)	<15	---	---	---	---	---						
17. COD	7	---	---	---	---	---						
18. Coliform, Total & Fecal												
19. Color (PVC)	3	10	3	2	4	3	20	20	20	45	20	20
20. Conductivity, Specific	3500	3600	3250	3400	3500	3000	3020	4000	4200	3800	3500	4000
21. Copper (ug/l)	5	0	3	1	7	3	2	1	3	4	4	2
22. Cyanide (mg/l)	.00	.00	---	.00	.00	.00	.00	.00	.00	.00	.00	.00
23. Discharge (CFS)	---	---	---	---	---	---						
24. Discharge, Instantaneous	2.9	2.2	1.2	3.3	1.9	1.7	---	---	1.1	1.9	1.1	---
25. Dissolved Oxygen (mg/l)	8.5	10.6	10.4	9.1	9.6	7.6	9.7	8.6	8.4	7.4	11.0	8.1
26. Fluoride (mg/l)	2.0	1.9	1.2	1.6	2.1	2.1	2.0	2.4	2.4	1.8	2.5	2.2
27. Gallium (ug/l)	<5	---	---	---	---	---						
28. Germanium (ug/l)	<20	---	---	---	---	---						
29. Hardness (Ca, Mg) (mg/l)	550	650	500	590	550	570	500	550	500	500	490	510
30. Hardness, Non-Carbonate (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0
31. Iron (ug/l)	65	20	10	10	30	40	660	20	10	20	90	10
32. Kjeldahl Nitrogen (mg/l)	.17	.71	---	2.6	.60	.30	1.4	.98	.45	.86	.57	.52
33. Lead (ug/l)	<16	0	0	0	9	4	5	1	1	0	2	1
34. Lithium (ug/l)	160	120	120	140	130	170	120	170	160	130	160	160
35. Magnesium (mg/l)	110	130	98	120	130	120	100	120	110	96	110	110
36. Manganese (ug/l)	14	20	10	10	30	10	50	0	0	0	20	10
37. Mercury (ug/l)	.0	.0	.3	.0	.0	.2	.0	.0	.0	.0	.0	.0
38. Molybdenum (ug/l)	30	---	---	---	---	---						
39. Nickel (ug/l)	<10	---	---	---	---	---						
40. Nitrate (mg/l)	9.3	6.6	9.7	7.9	4.4	2.5	1.5	.04	.49	2.2	4.4	1.2
41. Nitrite (mg/l)	.00	.03	.03	.03	.03	.03	.03	.00	.07	.03	.03	.20
42. Nitrite Plus Nitrate (mg/l)	2.1	1.5	2.2	1.8	1.0	.58	.35	.01	.13	.51	1.0	.34
43. Nitrogen, Ammonia	.00	.17	.19	.23	.00	.06	.00	.01	.02	.00	.04	.00
44. Odor (Severity)	2	2	---	---	0	0	0	0	0	0	0	0
45. Oil & Grease (mg/l)	3	3	---	2	2	1	1	0	---	1	E1	0
46. Ortho-Phosphate (mg/l)	.15	.37	.34	.15	.12	.06	.06	.00	.03	.00	.00	.00
47. Ortho-Phosphorus (mg/l)	.05	.12	.11	.05	.04	.02	.02	.00	.01	.00	.00	.00
48. Pesticides												
49. pH	8.4	8.7	8.8	8.7	8.8	8.7	---	9.4	9.1	8.5	8.9	8.4
50. Phosphorus, Total (mg/l)	.02	.13	---	.79	.09	.04	.10	.01	.01	.24	.03	.05
51. Potassium (mg/l)	4.6	3.5	3.8	4.4	7.4	3.9	4.5	3.5	3.6	5.5	3.9	5.0
52. Selenium (ug/l)	3	2	3	3	1	1	3	2	2	2	2	3
53. Silica (mg/l)	20	14	14	14	11	7.1	5.7	1.9	3.7	14	.3	1.1
54. Silver (ug/l)	<2	---	---	---	---	---						
55. Sodium (mg/l)	710	700	680	840	710	740	680	780	780	700	810	800
56. Sodium Adsorption Ratio	13	12	13	15	13	13	13	15	15	14	16	15
57. Sodium (%)	74	70	75	75	73	74	74	76	77	75	78	77
58. Solids, Dissolved (mg/l)	2320	2450	2270	2740	2330	2430	2250	2540	2530	2280	2550	2520
59. Solids, Dissolved T/D	18.6	14.6	7.66	25.0	12.0	11.2	---	---	7.51	12.1	7.57	---
60. Solids, Dissolved T/Ac-Ft	3.16	3.33	3.09	3.73	3.17	3.30	3.06	3.45	3.44	3.10	3.47	3.43
61. Solids, Suspended												
62. Strontium (ug/l)	3500	---	---	---								
63. Sulfate (mg/l)	490	640	470	630	600	570	560	600	580	540	510	530
64. Sulfide (mg/l)	.0	.1	.3	.2	.1	.1	.0	.3	.3	.1	0	.0
65. Temperature (°C)	9.0	3.5	6.0	9.0	9.0	17.0	9.5	21.5	24.0	19.0	17.0	14.0
66. Tin (ug/l)	<15	---	---	---	---	---						
67. Titanium (ug/l)	<10	---	---	---	---	---						
68. Turbidity JTU)	3	85	3	400	56	18	230	23	4	150	2	44
69. Vanadium (ug/l)	<8.0	---	---	---	---	---						
70. Zinc (ug/l)	6	0	6	20	0	6	30	10	10	20	40	10
71. Zirconium (ug/l)	<25	---	---	---	---	---						
72. Calcium (mg/l)	37	45	37	40	7.0	31						
73. Complete Element Span												
74. Radioactivity												
Gross Alpha (pci)	<36	---	---	---	---	---						
Radium 226*												
Gross Beta	8.8	---	---	---	---	---						
Thorium 230**												
Uranium**												
75. Total Organic Carbon (mg/l)	4.7	---	---	---	---	---						
If TOC 10 mg/liter, then												
Nitrogen (Base Extraction)												
Organic Carbon, Dissolved												
Organic Carbon, Suspended												
Phenols												
Sulfur (Acid Extraction)												
76. Total Ortho-Phosphorous (mg/l)	.06	.12	.30	.42	.01	01	.02	.01	.01	.05	.00	.02
77. Phosphate	---	---	---	---	28	.12	.31	.03	.03	.74	.09	.15
78. Phosphorus, Dissolved	---	---	---	---	---	---	---	---	---	---	---	---

TABLE 1.2-7
(CONTINUED)
SUMMARY WATER ANALYSIS
STREAM GAGING STATION, USGS 09306255
YELLOW CREEK NEAR WHITE RIVER

	9/10/75 1205	9/24/75 1045	10/15/75 1000
1. Alkalinity (mg/l)	1550	1560	1590
2. Aluminum (ug/l)	75		
3. Ammonia (mg/l)	0.0	0.04	0.04
4. Aromatics, Polycyclic			
5. Arsenic (ug/l)	4	7	5
6. Barium (ug/l)	200	200	200
7. Beryllium (ug/l)	<4		
8. Bicarbonate (mg/l)	1620	1900	1790
9. Bismuth (ug/l)	<20		
10. Boron (ug/l)	770	680	690
11. Cadmium (ug/l)	1	1	0
12. Carbonate (mg/l)	135	0	75
13. Carbon Dioxide (mg/l)	0.2	24	7.8
14. Chloride (mg/l)	150	140	130
15. Chromium (ug/l)	80	10	0
16. Cobalt (ug/l)	<10		
17. COD			
18. Coliform, Total & Fecal			
19. Color (PCU)			
20. Conductivity, Specific	4000	4000	4000
21. Copper (ug/l)	4	4	0
22. Cyanide (mg/l)	0	0	0
23. Discharge (CFS)			
24. Discharge, Instantaneous	0.0	1.3	0.92
25. Dissolved Oxygen (mg/l)	9.9	12.2	
26. Fluoride (mg/l)	2.3	2.3	2.1
27. Gallium (ug/l)	<10		
28. Germanium (ug/l)			
29. Hardness (Ca, Mg) (mg/l)	520	570	570
30. Hardness, Non-Carbonate (mg/l)	0	0	0
31. Iron (ug/l)	20	10	10
32. Kjeldahl Nitrogen (mg/l)	0.89	0.48	0.76
33. Lead (ug/l)	4	0	0
34. Lithium (ug/l)	120	160	150
35. Magnesium (mg/l)	110	120	120
36. Manganese (ug/l)	0	10	10
37. Mercury (ug/l)	0.0	0.0	0.1
38. Molybdenum (ug/l)	55		
39. Nickel (ug/l)	<20		
40. Nitrate (mg/l)	2.8	3.4	2.9
41. Nitrite (mg/l)	0.2	0.03	0.03
42. Nitrite Plus Nitrate (mg/l)	0.7	0.78	0.66
43. Nitrogen, Ammonia	.00	.03	.03
44. Odor (Severity)	0	0	0
45. Oil & Grease (mg/l)	1	0	0
46. Ortho-Phosphate (mg/l)			
47. Ortho-Phosphorus (mg/l)			
48. Pesticides			
49. pH	10.1	8.1	8.6
50. Phosphorus, Total (mg/l)			
51. Potassium (mg/l)	4.8	3.7	4.3
52. Selenium (ug/l)	2	2	2
53. Silica (mg/l)	8.9	9.3	6.4
54. Silver (ug/l)	< 2		
55. Sodium (mg/l)	820	830	800
56. Sodium Adsorption Ratio	16	15	15
57. Sodium ( )	77	76	75
58. Solids, Dissolved (mg/l)	2570	2600	2640
59. Solids, Dissolved T/D		9.69	6.56
60. Solids, Dissolved T/Ac-Ft	3.5	3.54	3.59
61. Solids, Suspended			
62. Strontium (ug/l)	3000		
63. Sulfate (mg/l)	510	520	580
64. Sulfide (mg/l)	0.0	0.0	0.2
65. Temperature (°C)	19.5	8.5	1.5
66. Tin (ug/l)	<20		
67. Titanium (ug/l)	<10		
68. Turbidity (JTU)	20	20	5
69. Vanadium (ug/l)	<10		
70. Zinc (ug/l)	0	10	10
71. Zirconium (ug/l)			
72. Calcium (mg/l)	25	31	32
73. Complete Element Span			
74. Radioactivity			
Gross Alpha (pci)			
Radium 226*			
Gross Beta			
Thorium 230**			
Uranium**			
75. Total Organic Carbon (mg/l)	29		
If TOC 10 mg liter, then			
Nitrogen (Base Extraction)			
Organic Carbon, Dissolved	22		
Organic Carbon, Suspended			
Phenols			
Sulfur (Acid Extraction)			
76. Total Ortho-Phosphorous (mg/l)	0.2	0.2	0.2
77. Phosphate			
78. Phosphorus, Dissolved	0.04	0.04	0.02

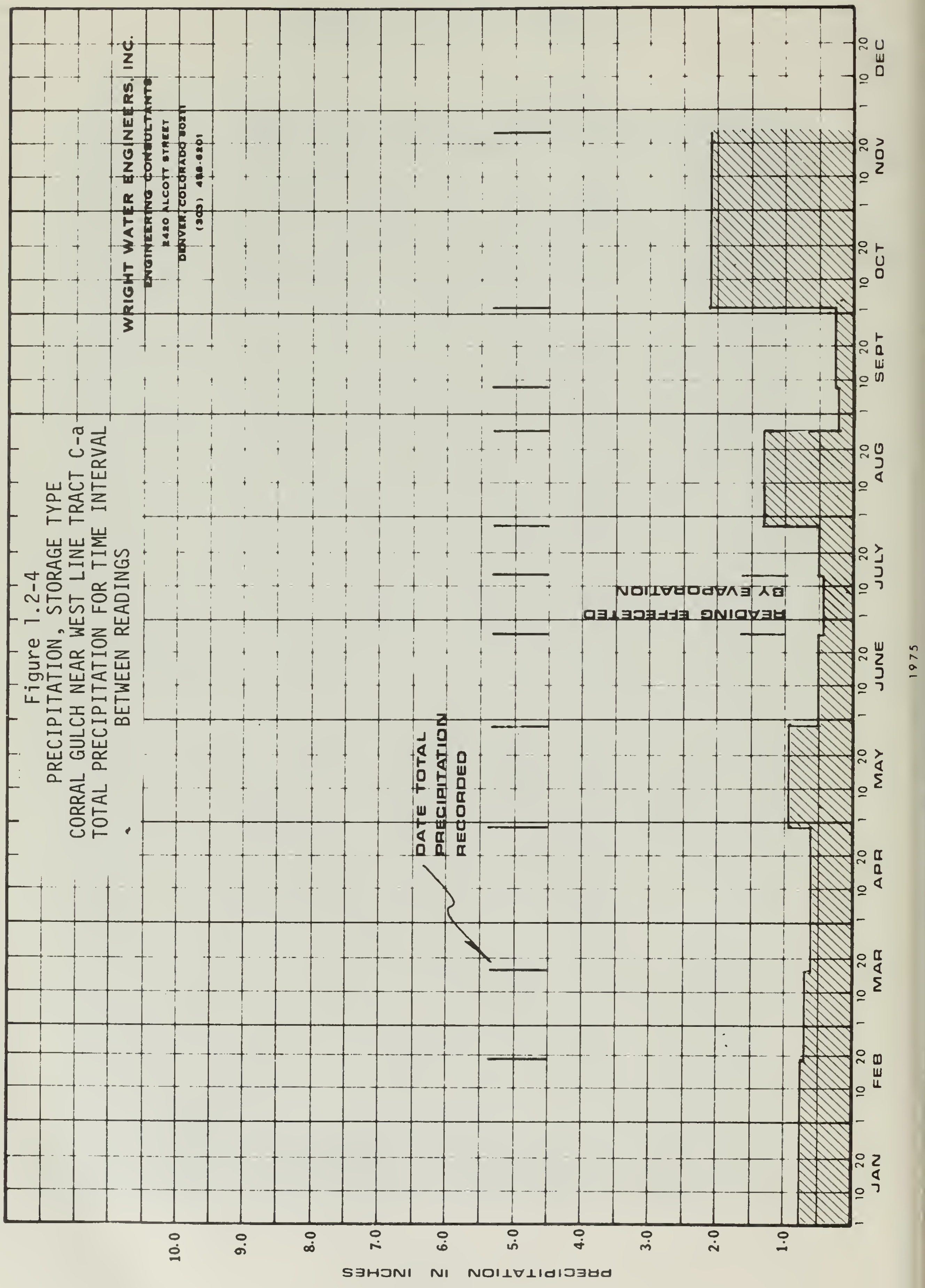


Figure 1.2-4
PRECIPITATION, STORAGE TYPE
CORRAL GULCH NEAR WEST LINE TRACT C-a
TOTAL PRECIPITATION FOR TIME INTERVAL
BETWEEN READINGS

Figure 1.2-5
PRECIPITATION
STAKE SPRINGS DRAW NEAR CONFLUENCE WITH CORRAL GULCH

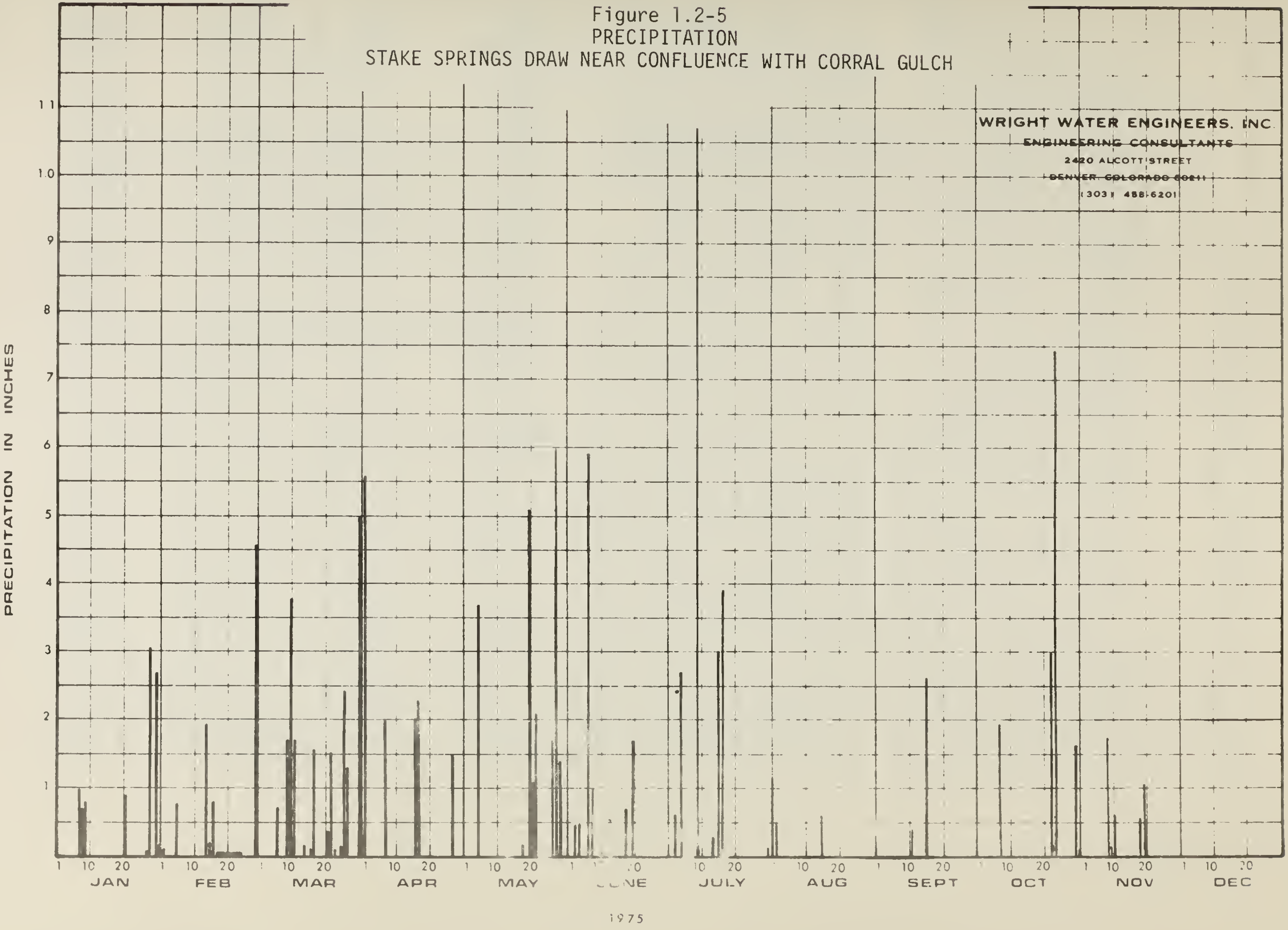


Table 1.2-8 is a summary of the precipitation data for each of the rain gaging stations associated with Tract C-a.

1.2.3 Alluvial Aquifers

The purpose of the alluvial aquifer monitoring program is to establish baseline conditions for the alluvial aquifer. Fifteen test holes associated with Tract C-a and 84 Mesa have been drilled and completed since December 1974. Only eight of the alluvial holes have encountered water, they are G-S; S-7, S-8, S-11, S-12, S-19, S-22, S-23, and S-24. Other holes associated with Dry Fork, Rinky Dink Gulch, and 84 Meas indicate the alluvium in those areas to be unsaturated. Drilling and completion of these alluvial test holes were described in previous Reports 2, 3, and 4. Figure 1.2-1 shows the location of all of the alluvial test holes as well as the stream gaging and rain gaging stations.

Two general trends appeared to be present in the alluvial aquifer based on review of the data. Temperature continued to drop in all test holes in the fall except in G-S S-24. The average drop from September through November was 2.6°C. Static water levels have been dropping since July except in G-S S-7 and S-19 most probably due to decline in rechange. The average drop during this quarter ranged from 0.5' to 4.0'. Conductivity fluctuates between 1,600 to 1,800 umhos/cm from September through November 1975. Increase in pH values over the same period are noted in the alluvial holes located along Stake Springs Draw and Corral Gulch while the pH values at G-S S-7, S-8, S-19, S-23 remained relatively stable. Figure 1.2-6 is a sample plot of the water levels and conductivity. Figure 1.2-7 is the sample plot of temperature and pH.

Table 1.2-9 and 1.2-10 are summaries of the wet chemical and spectrographic analysis from the alluvial aquifer monitoring program. Discussions of the alluvial aquifer water quality are presented in Progress Report 5, Interpretive Text, Section 1.2.3.

1.2.4 Deep Aquifer Drilling Program

The deep aquifer drilling program completed in conjunction with the corehole program was described in detail in RBOSP Progress Reports 2, 3 and 4. Thirteen coreholes, five monitor holes north of the tract, and four large diameter holes were drilled using air rotary methods. Several categories of hydrological data were collected during this program. The data included water production and quality, informal pumping test data, and production logging information. The method and intervals at which these data were collected were based upon the AOSS stipulations and approvals of the drilling program and knowledge from prior investigations.

Two aquifer systems in the area of Tract C-a were identified. From the differences in water quality and temperature, these systems were then delineated and separated. The upper aquifer describes a water-bearing zone of similar water quality and temperature characteristics

TABLE 1.2-8

SUMMARY OF PRECIPITATION DATA FOR 1975

Storage-Type Rain Gage Locations	Monthly Precipitation (In.)			Total Precipitation Received to Date 1975 (inches)
	Maximum	Minimum	Average	
Dry Fork near west line Tract C-a	1.95	0.23	0.76	7.62 (10 months' data)
Box Elder Gulch near west line Tract C-a	2.04	0.26	0.87	8.73 (10 months' data)
Corral Gulch near west line Tract C-a	2.1	0.23	0.81	8.1 (10 months' data)
Recording-Type Rain Gage Locations				
Stake Springs Draw near confluence with Corral Gulch	2.43	0.06	1.28	12.77 (10 months' data)
Yellow Creek near White River	1.91	0.04	1.05	10.51 (10 months' data)
Cathedral Bluffs located in NW1/4, NW1/4, Sec. 14, T2S, R100W	2.49	0.43	1.64	14.79 (9 months' data)

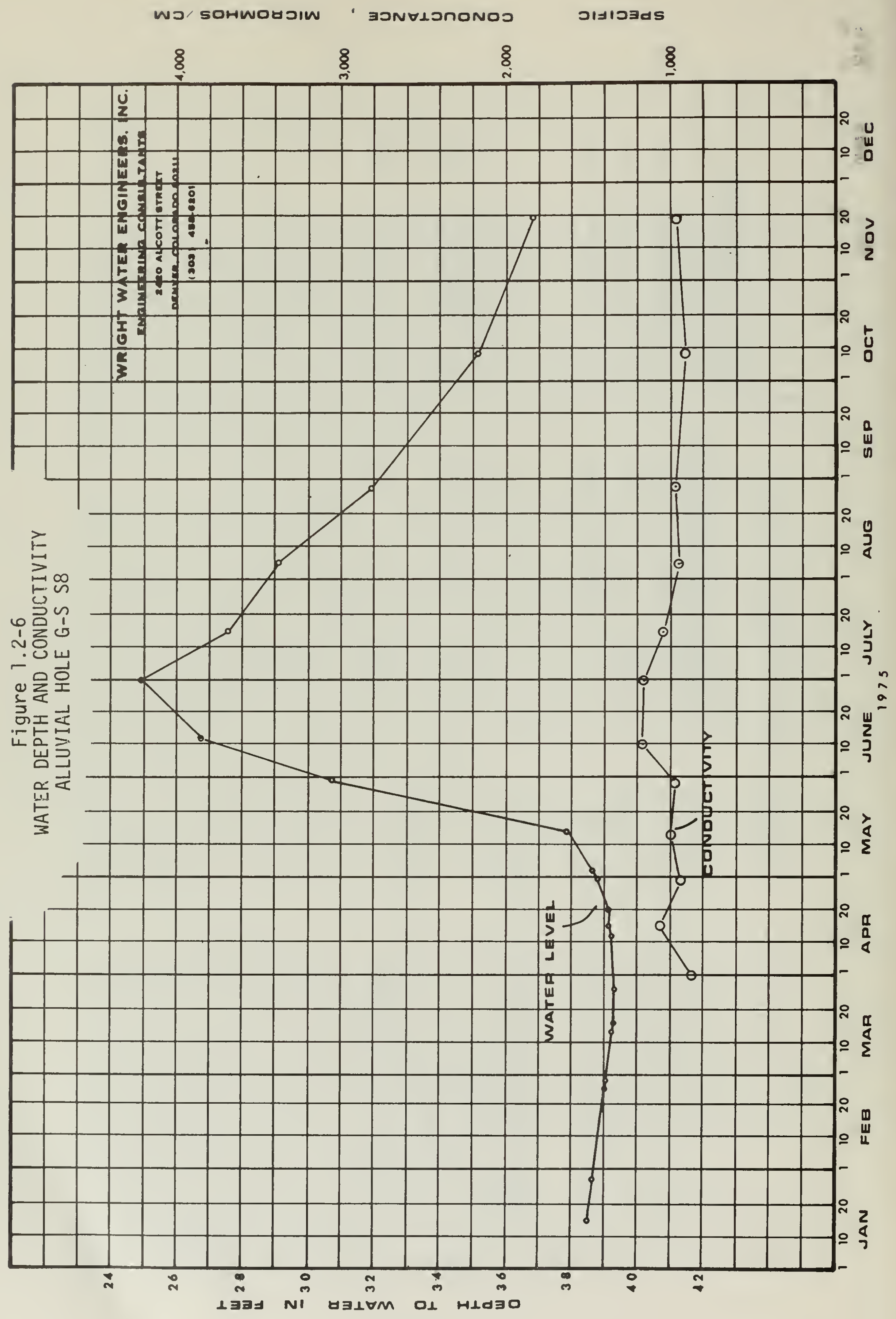


Figure 1.2-6
WATER DEPTH AND CONDUCTIVITY
ALLUVIAL HOLE G-S S8

Figure 1.2-7
TEMPERATURE AND PH
ALLUVIAL HOLE G-S S8

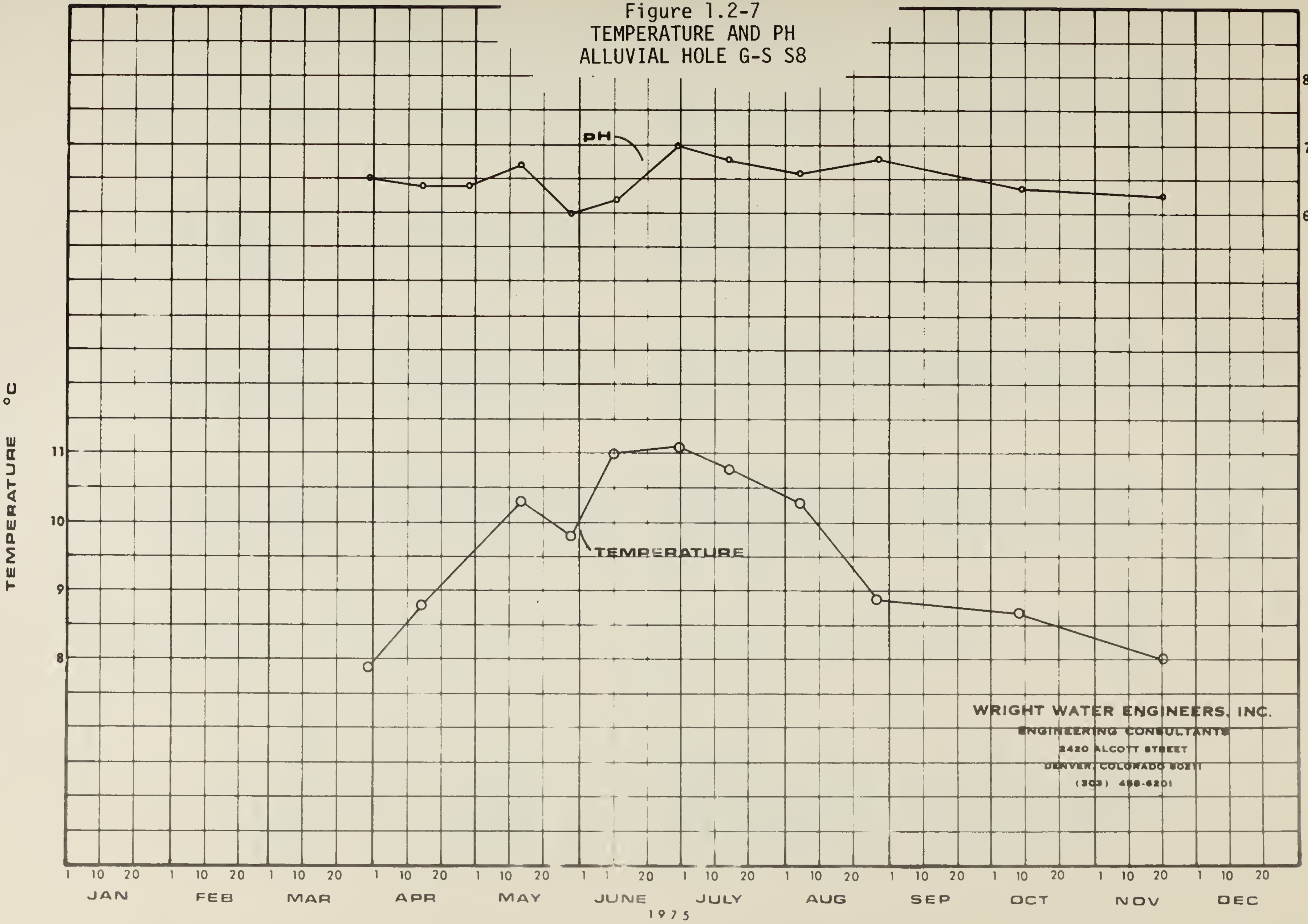


TABLE 1.2-9
WATER QUALITY ANALYSIS SUMMARY
WET CHEMICAL ANALYSIS
ALLUVIAL AQUIFERS
TRACT C-a and VICINITY

Item	Low	High	Average	No. Items Averaged
Alkalinity	329.000	620.000	470.771	65
Aluminum	<0.100	<0.100	---	4
Ammonia	<0.100	1.100	0.272	54
Arsenic	<0.010	0.010	---	65
Barium	<1.000	<1.000	---	65
Bicarbondat	370.000	755.000	567.769	65
Boron	<0.010	27.000	1.666	65
Cadmium	<0.010	0.090	0.007	65
Calcium	28.000	210.000	95.846	65
Carbonate	<0.100	605.000	15.969	65
Chloride	6.800	71.000	17.542	65
Chromium	<0.050	<0.010	---	64
Conductance	860.000	2370.000	1543.775	65
Copper	<0.100	3.200	0.158	65
Cyanide	<0.010	0.010	---	65
Dissolved Solids	640.000	1670.000	1153.154	65
Fluoride	<0.100	1.200	0.387	64
Gross Alpha	1.400	21.000	9.348	61
Gross Beta	1.000	35.000	10.680	15
Hardness	280.000	810.000	593.385	65
Iron	<0.050	28.000	7.326	65
Lead	0.020	0.900	0.244	64
Magnesium	3.700	145.000	86.292	65
Manganese	<0.050	17.000	2.429	65
Mercury	<0.010	0.002	---	65
Nickel	0.010	0.200	0.053	65
Nitrate	<0.100	21.000	5.228	65
pH	6.000	7.200	6.560	65
Phosphate	<0.100	0.200	0.008	65
Selenium	<0.100	<0.010	---	65
Silicon Dioxide	22.000	44.000	32.000	65
Silver	<0.100	0.070	0.004	64
Sodium	75.000	310.000	188.462	65
Sulfate	145.000	780.000	435.308	65
TOC	5.000	270.000	50.344	61
Zinc	<0.100	5.700	0.561	63

--- Less than minimum detectable amount

TABLE 1.2-10
SUMMARY OF QUALITATIVE SPECTROGRAPHIC ANALYSIS
ALLUVIAL AQUIFERS
TRACT C-a and VICINITY

Item	Low	High	Average	No. Items Averaged
Aluminum	0.005	1.000	0.138	64
Antimony	---	---	---	0
Arsenic	---	---	---	0
Barium	0.001	0.010	0.002	18
Beryllium	---	---	---	0
Bismuth	---	---	---	0
Boron	0.100	0.500	0.347	64
Cadmium	---	---	---	0
Calcium	10.000	Major	10.000	5
Cerium	---	---	---	0
Cesium	0.001	0.001	0.001	1
Chromium	---	---	---	1
Cobolt	---	---	---	0
Columbium	---	---	---	0
Copper	0.001	0.020	0.007	61
Dysprosium	1.000	1.000	1.000	1
Erbium	---	---	---	0
Europium	---	---	---	0
Gadolinium	---	---	---	0
Gallium	---	---	---	0
Germanium	---	---	---	0
Gold	---	---	---	0
Hafnium	---	---	---	0
Holmium	---	---	---	0
Indium	---	---	---	0
Iridium	---	---	---	0
Iron	0.010	0.500	0.048	64
Lanthanum	---	---	---	0
Lead	0.001	0.010	0.002	11
Lithium	0.001	0.100	0.009	54
Lutetium	---	---	---	0
Magnesium	5.000	Major	2505.375	8
Manganese	0.001	0.100	0.016	63
Mercury	---	---	---	0
Molybdenum	0.001	0.050	0.006	31
Neodymium	---	---	---	0
Nickel	0.070	0.070	0.070	1
Osmium	---	---	---	0
Palladium	---	---	---	0
Platinum	---	---	---	0
Potassium	0.010	2.000	0.660	64

TABLE 1.2-10
(Continued)

Item	Low	High	Average	No. Items Averaged
Praseodymi	---	---	---	0
Radium	0.100	1.200	0.343	47
Rhenium	---	---	---	0
Rhodium	---	---	---	0
Rubidium	---	---	---	0
Ruthenium	---	---	---	0
Samarium	---	---	---	0
Scandium	---	---	---	0
Selenium	---	---	---	0
Silicon	2.000	20.000	5.188	64
Silver	0.000	0.001	---	10
Sodium	2.000	Major	6.977	44
Strontium	0.010	0.100	0.094	61
Tantalum	---	---	---	0
Terbium	---	---	---	0
Thallium	---	---	---	0
Thorium	---	---	---	0
Thulium	---	---	---	0
Tin	0.001	0.001	0.001	2
Titanium	0.001	0.020	0.004	49
Tungsten	---	---	---	0
Uranium	---	---	---	0
Vanadium	---	---	---	0
Ytterbium	---	---	---	0
Yttrium	---	---	---	0
Zinc	0.001	0.010	0.001	21
Zirconium	---	---	---	0

--- Less than minimum detectable amount

Major - Concentration too large to quantify
(See wet chemical analysis Table 1.2-9)

which has an upper stratigraphic limit above the Mahogany Zone and a lower limit as far down as the R-5 zone. Water production from the upper aquifer ranged from 40 gallons per minute (gpm) to over 1,000 gpm and averaged 247 gpm. Water quality of the upper aquifer during drilling was as follows: conductivity ranged from less than 1,000 micromhos/centimeter to 1,700 micromhos/centimeter; dissolved solids averaged 1.160 milligrams/liter; and temperature varied from 54°F to 60°F. Informal pumping tests produced apparent transmissivities from less than 1,000 gallons per day per foot (gpd/ft) to 20,000 gpd/ft. averaging 5,140 gpd/ft.; and an apparent specific capacity average of 1.3 gallons per minute per foot (gpm/ft).

The lower aquifer describes a water-bearing zone with similar quality and temperature characteristics in the vicinity of the R-3 zone and the Blue Marker. Lower aquifer waters were combined with the waters of the upper aquifer during drilling and were measured and analyzed together. The combined flows produced from 150 gpm to over 1,000 gpm. The combined aquifer water ranged in conductivity from 1,30 to 4,600 micromhos/centimeter for holes drilled on Tract C-a. The maximum conductivity of over 30,000 micromhos/centimeter was measured in samples from monitor holes G-S M2 and G-S M3 located to the north and east of Tract C-a (the location of the holes in respect to the track is shown on Figure 1.2-8). Total dissolved solids for combined aquifer water averaged 2,370 milligrams/liter. Temperature varied from 59°F to 79°F. The informal pumping tests produced apparent transmissivities from less than 200 gpd/ft. to approximately 12,000 gpd/ft., and averaged 3089 gpd/ft., and apparent specific capacity averaged 1.5 gpm/ft. More detailed information on water qualities are available in Section 1.2.4 of RBOSP Progress Reports 2 and 4

1.2.5 Deep Aquifer Completion Program

The completion of 34 drill and coreholes was described in Section 1.2.5 of RBOSP Report 2. The completion of G-S M5 was discussed in Section 1.2.5 of RBOSP Report 4. Table 1.2-11 shows the current status of all core and drill holes.

1.2.6 Upper and Lower Aquifer Pumping Tests

The upper and lower aquifer pumping tests were described in Section 1.2.6 of RBOSP Report 3. Analysis of the pumping test data is reported in Section 1.2.8.6 of RBOSP Report 4.

1.2.7 Deep Aquifer Monitoring

The deep aquifer monitoring program was initiated in December 1974, at which time only static water levels were monitored. Sampling programs for the deep aquifer monitor holes started in March 1975. Water samples for laboratory analysis were collected once a month for a period of six months. Field measurements included static water levels, temperature, pH, and conductivity. The monthly sampling program ended in August 1975. Presently, the deep aquifer monitor

TABLE 1.2-11

DRILL HOLE COMPLETION SUMMARY
TRACT C-a AND VICINITY
Thirty On-Tract Holes

Drill Hole	Completion	Drill Hole	Completion
G-S 1	U&L	Am 4	P&A
G-S 2-3	U&L	CE - 701	Upper Aquifer Pumping Test
G-S 4-5*	U&L*	CE - 702	U&L
G-S 6	U&L	CE - 703	P&A
G-S 7	P&A	CE - 705-A	Upper Aquifer Pumping Test
G-S 8	Lower Aquifer Only	CE - 707	U&L
G-S 9	U&L	CE - 708	U&L
G-S 10	U&L	CE - 709	U&L
G-S 11	U&L	TO 1	U&L
G-S 12*	U&L*	TO 2	U&L
G-S 13	U&L	TO 3	Upper Aquifer Pumping Test
G-S 14	P&A	G-S D16	Lower Aquifer Pumping Test
G-S 15	U&L	G-S D17	Lower Aquifer Pumping Test
Am 2-A	U&L	G-S D18	Lower Aquifer Pumping Test
Am 3	U&L	G-S D19	Lower Aquifer Pumping Test

Four Off-Tract Holes

Drill Hole	Completion
G-S M1	U&L
G-S M2	U&L
G-S M3	U&L
G-S M4	U&L
G-S M5	AU

Totals

Completions in Upper and Lower Aquifers	22
Completions in Upper Aquifer Only	3
Completions in Lower Aquifer Only	5
Completions in Uinta Fm. Aquifers	1
Holes Plugged and Abandoned	4
Total Number of Holes	35

Am = Amoco Production Company
CE = Cameron Engineers, Inc.
G-S = Gulf-Standard (Indiana)
TO = The Oil Shale Corporation
U&L = Upper and Lower Aquifer Completions
P&A = Plugged and Abandoned
AU = Aquifers, Uinta Fm.

*Holes Temporarily Modified for Upper Aquifer Pumping Test holes are sampled semi-annually; while water temperature and water levels are measured monthly. Figure 1.2-8 shows the locations of each of the monitor holes.

Computer print-outs of water quality data from the deep aquifer monitoring program are presented in Progress Report 5 - Raw Data. Table 1.2-12 and 1.2-13 are summaries of the wet chemical and spectrographic analysis respectively. General observations are discussed in Section 1.2.7 Progress Report 5 - Interpretive Text.

1.2.8 Hydrologic Program Summary and Analysis

Section 1.2.8 summarizes and analyzes the data from the baseline data collection program. It is sub-divided into three separate parts. Section 1.2.8.1, Surface Water, includes a discussion on precipitation and stream flow. Section 1.2.8.2 includes description of the alluvial aquifers and Section 1.2.8.3 is a description of the deep aquifers

1.2.8.1 Surface Water

Precipitation data from the three recording type rain gages indicate that an estimate of the annual precipitation for the Yellow Creek drainage would range from 11.9 to 17.2 inches per year. The lowest value would be representative of the area around the Yellow Creek Creek stream gaging station near the White River which is at the lowest elevation of the rain gages. The higher value would represent the rain gage on Cathedral Bluffs which is the highest elevation of the RBOSP rain gages. The other rain gages at intermediate elevations have estimated annual precipitation rates somewhere between 11.9 and 17.2 inches per year.

Precipitation is effected basically by two weather systems. The system generally results in widespread, uniform precipitation. The frontal convection system or thunderstorm results in very localized erratic precipitation over on area of a few square miles or less. The duration of the frontal system precipitation could be a week or so. Thunderstorm duration is usually measured in minutes or hours. From the data obtained to date the heaviest precipitation from any one event is the result of thunderstorms rather than the frontal system.

The streams on and around Tract C-a can be classified as intermittent; however, some reaches of the streams are perennial. The maximum stream flows in the vicinity of Tract C-a occur during snow melt runoff. Data from the Box Elder stream gaging station may indicate that runoff water from snow melt may have a lower conductivity than runoff from a thunderstorm. The apparent reason for this is the gradual nature of snow melt runoff in comparison to the more rapid runoff from heavy thunderstorms. Rapid runoff will tend to be higher in sediment and presumably higher in dissolved solids. Both Corral Gulch and Box Elder Gulch generally have some flow leaving the tract. The combined flow measured at the Corral Gulch stream gaging station

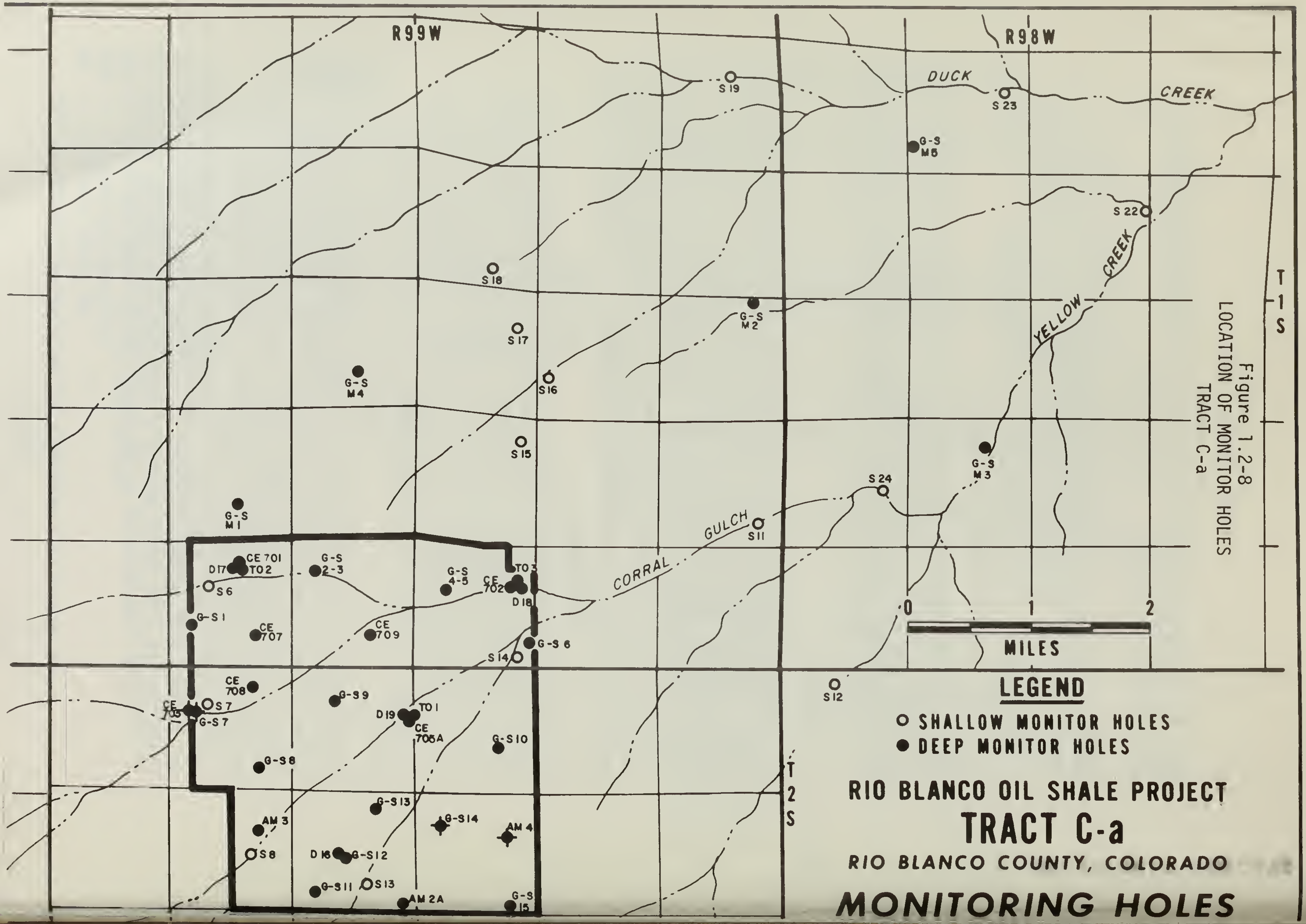


Figure 1.2-8
LOCATION OF MONITOR HOLES
TRACT C-a

TABLE 1.2-12
SUMMARY OF WET CHEMICAL ANALYSIS
MONITORING PROGRAM
UPPER AND LOWER AQUIFER
TRACT C-a and VICINITY

	LOWER AQUIFER				UPPER AQUIFER			
Item	Low	High	Average	No. of Items Avg'd.	Low	High	Average	No. of Items Avg'd.
Aluminum	-0.100	0.600	0.178	9	-0.100	1.000	0.144	17
Ammonia	-0.100	9.600	0.697	79	-0.100	1.800	0.394	119
Arsenic	-0.010	0.030	0.000	80	-0.010	0.040	0.001	123
Bicarbonate	260.000	2980.000	1074.438	80	85.000	2760.000	622.992	123
Cadmium	-0.010	0.010	0.001	80	-0.100	0.100	0.002	123
Calcium	0.800	115.000	19.570	80	-0.010	260.000	64.512	123
Carbonate	-0.100	710.000	102.192	80	-0.100	335.000	24.969	123
Chloride	1.400	160.000	31.006	80	-1.000	87.000	17.115	123
Chromium	-0.050	-0.010	--	78	-0.050	0.050	--	122
Copper	-0.100	0.300	0.027	80	-0.100	0.800	0.029	123
Fluoride	0.200	85.000	15.070	80	0.100	60.000	3.300	123
Iron	-0.050	16.200	4.156	80	-0.050	18.000	6.170	123
Lead	-0.100	26.000	1.157	80	0.010	3.800	0.434	123
Magnesium	2.400	130.000	33.292	80	3.500	155.000	56.163	123
Mercury	-0.010	0.002	--	80	-0.010	0.045	--	123
Nitrate	-0.100	2.000	0.387	80	-0.100	7.000	0.568	123
Phosphate	-0.100	0.700	0.037	80	-0.100	1.000	0.023	123
Selenium	-0.100	-0.010	--	80	-0.010	-0.001	--	123
Silicone Dioxide	-0.100	32.000	9.670	80	-0.100	58.000	27.076	123
Sodium	155.000	1560.000	527.500	80	110.000	1170.000	279.024	123
Sulfate	-4.000	600.000	190.887	80	-4.000	900.000	356.748	123
Zinc	-0.100	68.000	1.675	80	-0.100	15.000	0.796	123
Gross Alpha	0.100	30.000	5.765	72	0.200	29.000	5.334	97
Gross Beta	3.000	830.00	49.432	37	2.000	73.000	22.464	28
Hardness	20.000	690.000	185.313	80	32.000	1110.000	396.244	123
pH	6.000	11.000	7.324	80	6.000	8.800	6.789	123
Conductance	900.000	5180.000	2096.662	80	810.000	4200.000	1584.935	123
Dissolved Solids	630.000	3640.000	1460.313	80	540.000	2850.000	1147.642	123
Manganese	-0.050	0.500	0.093	80	-0.050	1.000	0.174	123
Alkalinity	52.000	4500.000	975.989	80	70.000	2360.000	535.834	123
Cyanide	-0.010	0.030	0.000	79	-0.010	-0.010	--	122
Boron	-0.100	9.400	1.479	80	-0.100	4.800	0.681	123
Barium	-1.000	-0.100	--	80	-1.000	-0.100	--	123
Silver	-0.010	0.100	0.002	80	-0.100	0.100	0.006	123
Nickel	-0.100	0.100	0.026	80	-0.010	0.200	0.027	123
TOC	3.000	73.000	12.613	71	1.000	50.000	10.538	106

TABLE 1.2-13
SUMMARY OF SPECTROGRAPHIC ANALYSIS
MONITORING PROGRAM
UPPER AND LOWER AQUIFER
TRACT C-a and VICINITY

	LOWER AQUIFER				UPPER AQUIFER			
Item	Low	High	Average	No. of Items Avg'd.	Low	High	Average	No. of Items Avg'd.
Aluminum	0.001	1.000	0.077	80	0.001	1.000	0.122	123
Antimony	0.200	0.200	0.200	1	--	--	--	0
Arsenic	--	--	--	0	--	--	--	0
Barium	0.001	0.010	0.002	13	0.001	0.010	0.003	22
Berylium	--	--	--	0	--	--	--	0
Bismuth	--	--	--	0	--	--	--	0
Boron	0.100	0.500	0.351	78	0.100	2.000	0.363	123
Cadmium	--	--	--	0	--	--	--	0
Calcium	0.100	Major	5.265	23	1.000	Major	7.882	17
Cerium	--	--	--	0	--	--	--	0
Cesium	--	--	--	0	--	--	--	0
Chromium	--	--	--	0	--	--	--	0
Cobalt	--	--	--	0	--	--	--	0
Columbium	--	--	--	0	--	--	--	0
Copper	0.001	0.020	0.005	71	0.001	0.020	0.006	113
Dysprosium	--	--	--	0	--	--	--	0
Erbium	--	--	--	0	--	--	--	0
Europium	--	--	--	0	--	--	--	0
Gadolinium	--	--	--	0	--	--	--	0
Gallium	--	--	--	0	--	--	--	0
Germanium	--	--	--	0	--	--	--	0
Gold	--	--	--	0	--	--	--	0
Hafnium	--	--	--	0	--	--	--	0
Holmium	--	--	--	0	--	--	--	0
Indium	--	--	--	0	--	--	--	0
Iridium	--	--	--	0	--	--	--	0
Iron	0.010	0.500	0.046	73	0.010	1.000	0.094	122
Lanthanum	--	--	--	0	--	--	--	0
Lead	0.000	0.500	0.073	10	0.001	0.200	0.027	21
Lithium	0.001	0.100	0.011	63	0.001	0.500	0.015	92
Lutetium	0.010	0.010	0.010	1	0.001	0.010	0.005	2
Magnesium	0.100	Major	2.764	22	0.100	Major	6.006	18
Manganese	0.001	0.100	0.013	63	0.001	0.200	0.020	105
Mercury	--	--	--	0	--	--	--	0
Molybdenum	0.001	0.100	0.007	31	0.001	0.500	0.020	62
Neodymium	--	--	--	0	--	--	--	0
Nickel	--	--	--	0	--	--	--	0
Osmium	--	--	--	0	--	--	--	0
Palladium	--	--	--	0	0.100	0.100	0.100	1
Platinum	--	--	--	0	--	--	--	0
Potassium	0.050	5.000	1.099	78	0.100	5.000	1.054	122
Praseodymium	--	--	--	0	--	--	--	0
Radium	0.090	0.900	0.375	24	0.100	0.800	0.200	26
Rhenium	--	--	--	0	--	--	--	0
Rhodium	--	--	--	0	--	--	--	0
Rubidium	--	--	--	0	--	--	--	0
Ruthenium	--	--	--	0	--	--	--	0
Samarium	--	--	--	0	--	--	--	0
Scandium	--	--	--	0	--	--	--	0
Selenium	--	--	--	0	--	--	--	0
Silicon	-0.500	10.000	4.287	80	1.000	20.000	5.268	123
Silver	0.000	0.001	0.001	6	-0.001	0.001	0.001	12
Sodium	2.000	Major	6.791	43	2.000	Major	6.843	83
Strontium	0.001	1.000	0.096	70	0.001	1.000	0.109	113
Tantalum	--	--	--	0	--	--	--	0
Terbium	--	--	--	0	--	--	--	0
Thallium	--	--	--	0	--	--	--	0
Thorium	--	--	--	0	--	--	--	0
Thulium	--	--	--	0	--	--	--	0
Tin	--	--	--	1	0.001	0.001	0.001	1
Titanium	0.001	0.010	0.003	38	0.001	0.020	0.004	73
Tungsten	--	--	--	0	--	--	--	0
Uranium	-1.500	-1.500	--	1	--	--	--	0
Vanadium	--	--	--	0	--	--	0.001	1
Ytterbium	--	--	--	0	--	--	--	0
Yttrium	--	--	--	0	--	--	--	0
Zinc	0.001	0.200	0.014	17	0.001	0.200	0.015	38
Zirconium	--	--	--	0	--	--	--	0

-- Less than minimum detectable amount

Major - Concentration too large to quantify (see wet chemical analyses) east of Tract C-a averages approximately 1 cfs during the year. The average flow at the Yellow Creek stream gaging station near the White River is approximately 1.8 cfs. The Yellow Creek base flow which appears to be approximately 0.7 cfs has a dissolved solids content in excess of 3,500 mg/l, indicating a water source other than the surface system. It has been proposed by the USGS-WRD and others that the perennial flows in the lower reaches of Yellow Creek are due to artesian contributions by the deep ground water aquifers. The data collected at the Yellow Creek gaging station during the past year would tend to indicate that this is the case.

1.2.8.2 Alluvial Aquifers

The alluvial aquifer drilling program determined the depth of the alluvium and whether or not water was present in the alluvium. Results of the alluvial monitoring program show that the major drainages have water-saturated alluvium. The minor drainages have remained dry throughout the monitoring program. Observations from the continuous water level monitors at the alluvial holes indicate that the alluvial aquifers respond only indirectly to regional and local precipitation events. The water quality in the alluvium tends to be generally poorer than the water quality of the surface streams. The alluvium generally shows an increase in dissolved solids in the down gradient direction. During the pumping tests conducted in the deep oil shale aquifers no measurable hydrologic connection between the alluvial aquifers and the deep oil shale aquifers were noted.

1.2.8.3 Deep Aquifers

The various drilling programs conducted on Tract C-a have indicated that two major aquifer systems exist under Tract C-a. The upper aquifer occurs in the vicinity of the Mahogany Zone generally being located both above and below the Mahogany Zone. The lower aquifer is associated with the R-3 Zone. Both the upper and lower aquifers are artesian.

The completion program which consisted of isolating the two aquifer systems in and around Tract C-a was successful with the exception of the NE corner of the tract. At this location an interconnection between the upper and lower aquifers still exists. This interconnection may be the result of naturally occurring faults in the area, inadequate isolation of the two aquifers in one of the three holes located in the NE corner of the tract and/or possible fracturing as a result of experimental fracturing work done by WRD-USGS in 1973. It is not known at this time which of the above explanations should be considered the more viable.

As a result of the interconnection between the two aquifer systems via known open wells since as early as 1971, it is estimated that approximately 5,000 acre-feet of water flowed from the upper aquifer system to the lower aquifer system prior to October 1974. This compares with approximately 145 acre-feet of water produced from the lower aquifer system during the RBOSP pumping test program and 30 acre-feet of water from the upper aquifer pumping tests. At the present time all of the holes on and around Tract C-a have been completed in such a manner as to eliminate this mode of communication between the two aquifer systems.

The long-term pumping tests allowed for the calculation of transmissivity and coefficients of storage at various monitoring holes located on and around the tract. The extrapolation of these values resulted in apparent transmissivities of 2,500 gpd/ft. and 7,000 gpd/ft. for the upper and lower aquifers respectively. It should be noted that the upper aquifer system responded only locally to stresses created during pumping while the lower aquifer system responded over a large area from single pumping tests. Therefore, the transmissivity and coefficients of storage for the lower aquifer system are considered to be much more reliable than those for the upper aquifer system.

An analysis of the various pumping tests in both aquifer systems revealed an elongation of the cone of depression along a NNW-SSE axis. A comparison of the trends of the major fracture-joint sets on Tract C-a indicate three major directions. These are NW-SE, SW-SW, and N-S (see Tract C-a Geologic Report, RBOSP Progress Report 5 - Interpretive Text). The directions are given in order of decreasing number of fracture and joint orientations. Therefore, a resultant preferred directional flow in these aquifers would be along the NNW-SSE as observed during the pumping tests.

As indicated by the results of the pumping tests conducted in G-S 12, it appears that some of the faults act as barriers to water movement in the upper aquifer systems. It appears highly possible that the upper aquifer system may respond to dewatering in a manner similar to an aquifer which has been divided into cells that are only partially connected hydrologically.

Environmental Baseline Data Gathering Project

ABSTRACT

Since October 1974, multidisciplinary environmental baseline studies have been in progress on Tract C-a and the immediate area in an effort to characterize the baseline conditions of the oil shale lease area. These include air quality and meteorology, terrestrial and aquatic ecosystems, soils, archaeology, revegetation, seismicity and visibility studies and paleontology.

Each quarter, a report of progress is submitted to the Area Oil Shale Supervisor. The current report presents data collected during the fifth quarter of progress, September through November 1975.

Fifty-seven air quality or meteorology parameters are monitored over four locations in the vicinity of the tract. Analyses of data collected during the quarter indicate that most air quality parameters fell within the expected low background ranges. Although ozone levels were higher than expected, they did not exceed state or federal standards. Parameters which did exceed either state or federal standards were nonmethane hydrocarbons (11 times) and particulates (3 times). Standards for nonmethane hydrocarbons are, however, very close to instrument detection limits. The high particulate concentrations occurred on windy days.

Winds at the two plateau sites were predominantly from the southwest and of similar magnitude (7.8 and 8.6 mph). Winds from the two valley sites were similar in magnitude (6.7 and 5.7 mph) but the directions were related to local terrain. The area exhibits a weak mean air surface inversion which breaks up early in the morning.

Maximum daily precipitation was less than half an inch with the seasonal total being slightly more than 3 inches. Maximum snowfall for the quarter was 7 inches. The evaporation rate decreased as the quarter progressed.

On-tract visibility measurements indicated a range of 8 to 150 miles, while results of the Piceance Creek visibility studies indicated a visual range often in excess of 45 miles with daily variations as high as 30 to 40 miles.

The terrestrial baseline study program involves vegetation, small mammals, large mammals, predators, birds, reptiles, amphibians and invertebrates.

This quarter, fifteen additional species of plants from the study area were identified. Flora for the area is represented by 5 tree species, 36 shrub species, 169 forb species and 46 grass or grass-like species. The ten major vegetation types identified are being studied for phytosociological relationships.

Twenty-eight species of small- and medium-sized mammals occur on the study area. Studies indicate that amounts and kinds of vegetation are the most important factors in mammal distribution and abundance. The most abundant small mammal species found in the area are the least chipmunk and the deer mouse. Rabbit population levels are low.

Feral hourses were seen on 84 Mesa and southwest of the tract during the quarter. Few mule deer were found on tract, but small groups were found both east and west of the tract, with the greater number occurring to the west. Summer use of the tract was relatively light.

The most abundant mammalian predators appear to be the coyote and the weasel.

The bird census conducted during the quarter indicated that many species had already migrated out of the area by October. However, more golden eagles were observed in the study area during the fall quarter than during the summer quarter. Prairie and peregrine falcons were seen infrequently in the area. Surveys for greater sandhill cranes were conducted. Two flocks apparently used 84 Mesa as a resting place during their fall migration, but not as a staging area.

Fewer numbers of invertebrates (insects, spiders, etc.) were collected during the fall quarter than during the summer quarter.

Forage production studies indicate that new growth produced by palatable plants in the study area is lower than previously expected. This is probably related to prolonged heavy grazing and subsequent reduction in the vigor of forage plants. The major proportion (~73%) of the range in the study area was determined to be in "fair" condition, only 2% was in "good" condition and approximately 24% was in poor condition. Over 98% of the browse was determined to be in "good" condition.

Thirty-five aquatic stations are sampled for water and sediment chemistry, physical characteristics, plankton, periphyton, macrophytes and fish. These stations are located on the White River, Yellow Creek and other locations in the vicinity of the tract. Results presented represent samples taken from July through September 1975. During the survey, five of the sampling stations were dry. Chemical data from Yellow Creek and White River stations were generally in agreement with U.S. Geological Survey data taken from the area.

Phytoplankton taxa identified from July - August samples totaled 133; those identified from August - September samples totaled 123. Zooplankton taxa identified from the two sample periods totaled 74 and 52, respectively. Density data agree well with data from previous quarters. Periphyton identified from the July - August samples totaled 65; from August - September samples, 61. Benthic taxa from the two sample periods included 120 and 107, respectively.

Results of sediment chemistry analysis indicate that concentrations of the herbicides Tordon 22k and Silvex are low (<0.02 g/g). Concentrations of arsenic, lead and zinc are similar for Yellow Creek and the White River.

Macrophytes were found at 4 stations during the July - August sampling period and at 11 stations during the August - September sampling period.

A total of 201 individual fish, representing 10 species, were taken from the White River during July - August. During August - September, 12 species (949 fish) were taken from Yellow Creek and the White River. The catches were dominated by rough and forage fishes and many were young-of-the-year.

Soils studies include an inventory of soil types, physical and chemical characteristics, and distribution. Eleven soil types and one rock-outcrop occur in the area. Each of these is discussed in relation to associated vegetation.

Laboratory analysis of archaeological material collected during the summer 1975 field survey continued during the quarter. Sites which had yielded artifacts were classified as either primary, secondary or tertiary sites on the basis of importance for excavation. Fourteen primary, 47 secondary and 135 tertiary sites were identified from the areas studied. Evidence indicates that at least four cultures have occupied the area: Archaic, Fremont, Ute and Anglo. However, since total inventory of artifacts recovered from the study area is not impressive, archaeological significance is due more to the lack of past exploration than the abundance of archaeological material.

The revegetation program involves a literature survey and field and laboratory experimentation. Two revegetation test plots have been established in the southeast corner of the tract. Soil samples were taken from these locations for chemical analysis and the test plots were seeded during the fall quarter.

Trace metal studies involve review of the literature pertinent to trace metals which may occur in the study area and their effects on biological organisms and ecological systems and chemical analyses to obtain data on current baseline levels of trace metals. The literature survey was initiated and a discussion of literature reviewed to date is presented. Initial trace metal analyses will be conducted jointly with chemical analyses of soils from the area. Additional analyses for trace metals in living organisms will be performed as deemed necessary after review of the data.

The paleontological studies included reports of surface material by scientists involved in field work in the area and the examination of core hole samples for the presence of paleontological material. No important finds were reported. A study of subsurface core hole lithologic description logs revealed only the presence of a few small fish fossils. These types of fossils have been previously reported in the literature and are not considered unique. In view of information available to date, the possibility of finding a significant paleontologic discovery is deemed remote.

2.0 ENVIRONMENTAL BASELINE DATA GATHERING PROJECT

The environmental baseline data gathering project is a multidisciplinary program involving air quality, meteorology, terrestrial biota, water quality and aquatic biota, soils, archaeology, revegetation, trace metal concentrations, and others (Figure 2.0-1). These programs are designed to meet all lease stipulations and to gather sufficient data for characterization of baseline environmental conditions.

Progress reports are prepared on a quarterly basis. For the most part, discussions presented herein are restricted to the fifth quarter of data since annual trends and interpretations are to be presented in the DDP and the annual report. Persons wishing additional information should consult these reports, which will be available soon.

Detailed descriptions of objectives and methods have been presented in previous reports and are not repeated here unless a change has occurred. They will also appear in the annual report.

Toxicology studies are not discussed in this report because they are outside the scope of the Environmental Baseline Data Gathering Project. Toxicology studies are being performed in the interest of human health and safety and will be discussed in Section 9, Chapter 2 of the DDP. Results of paleontological investigations and range studies are presented for the first time in this report.

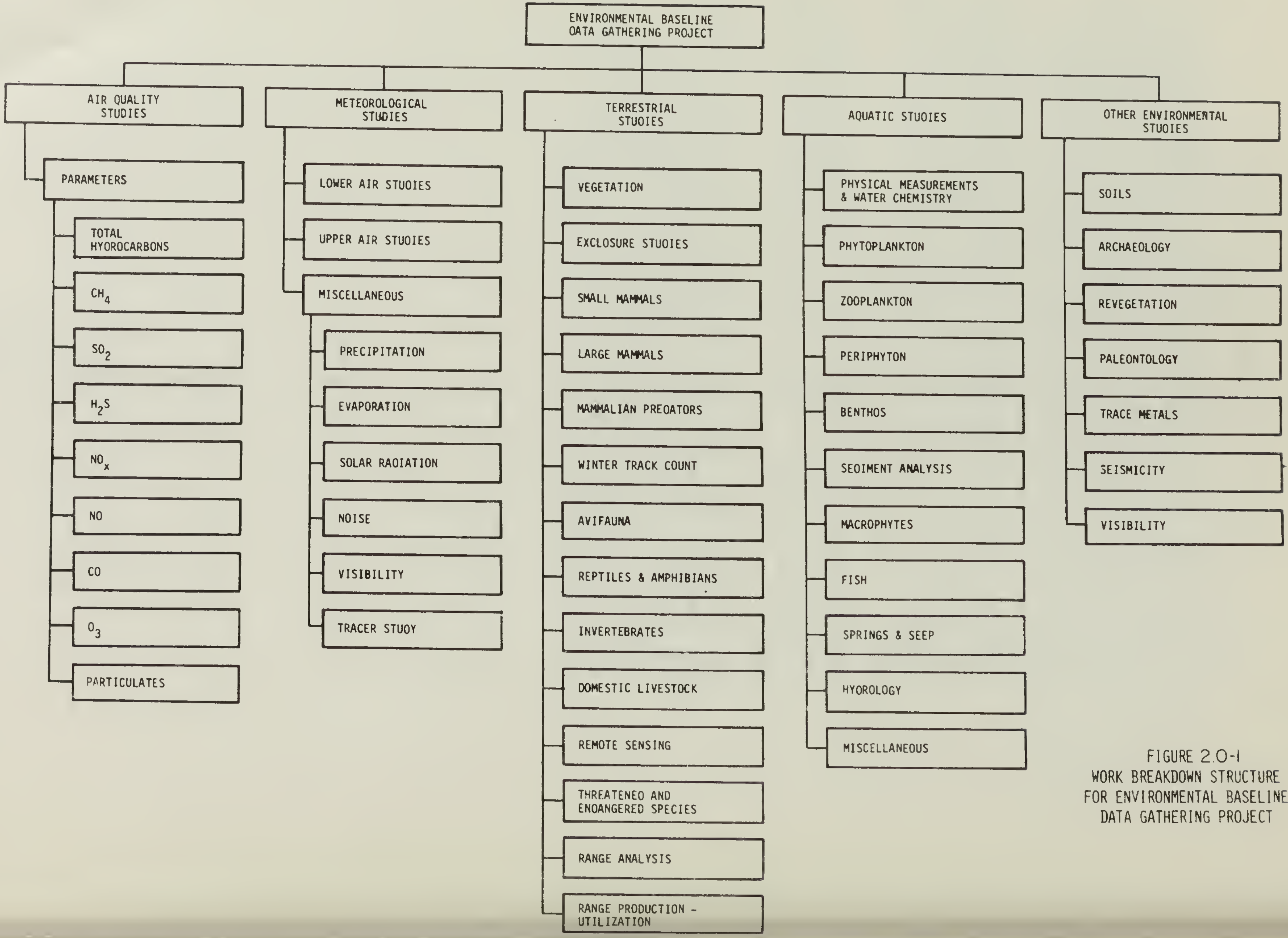


FIGURE 2.0-1
WORK BREAKDOWN STRUCTURE
FOR ENVIRONMENTAL BASELINE
DATA GATHERING PROJECT

2.1 AIR QUALITY

Air quality studies are designed to meet and, in some cases, exceed the lease stipulations.

The Air Quality and Meteorological Data Acquisition Sytem for the RBOSP consists of: four monitoring sites, each with tower-mounted meteorological instruments and trailer-contained air quality instrumentation; interface electronics; RF data telemetry links; and a central minicomputer for data storage and processing (Figure 2.1-1).

Site No.	THC	CH_4	SO_2	H_2S	NO_x	NO	CO	O_3	Particulates
1	X	X	X	X	X	X	X	X	X
2	X	X	X	X					X
3	X	X	X	X	X	X	X	X	X
4	X	X	X	X					X

Data from all stations are sent to the minicomputer at the central station (Site 1). The minicomputer exponentially averages the air quality data from the continuously operating analyzers. The minicomputer stores the data on magnetic tape, the primary recording medium. A high speed printer provides a hardcopy printout. Backup analog recorders are located in air quality trailers.

The Fall 1975 quarter (season), as used in this section, is defined as September 1, 1975 through November 30, 1975,

2.1.1 Parameters

2.1.1.1 Objectives

Air quality parameters are the same as those described in Progress Report 3-Summary. See Section 2.1.1.1 for specific objectives.

2.1.1.2 Methods

Table 2.1-1 lists the instruments and air quality measurement techniques used for monitoring gases. Also presented are the lower detectable limits (LDL) for the instruments. The LDL are interpreted as the lowest concentration that can be differentiated from noise irrespective of sampling time.

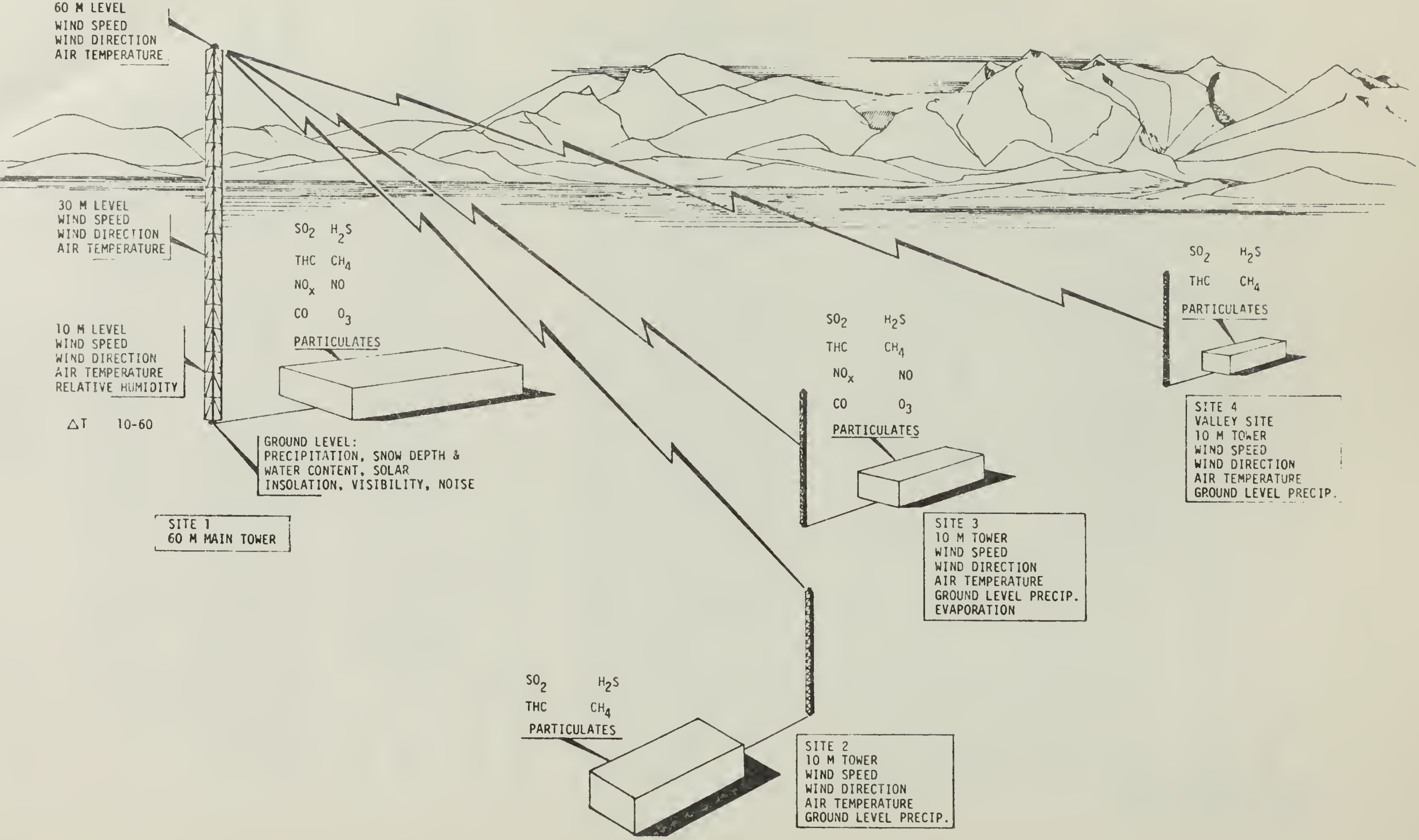


Figure 2.1-1. Meteorological and air quality data acquisition system for Tract C-a, RBOSP.

Table 2.1-1. Air quality instrumentation and measurement techniques, RBOSP.

Parameter	Manufacturer	Model	Technique	Lower Detectable Limit (ppm)	Accuracy ± (ppm)
SO_2/H_2S	Bendix	8700X	Flame photometric with separation column for SO_2 and H_2S	0.005	0.020
NO_x/NO	Bendix	8101-B	Chemiluminescence	0.005	0.010
THC/CH_4	Bendix	8201	Flame ionization detector with separation column for CH_4	0.005	0.10 (THC) 0.02 (CH_4)
Photochemical Oxidant (O_3)[1]	Bendix	8002	Chemiluminescence	0.001	0.004[2]
CO	Bendix	8501-5CA	Nondispersive infrared detector	0.5	0.500[2]

[1] Photochemical oxidant corrected for interference due to nitrogen oxide and nitrogen dioxide as measured by the Federal Reference as ozone (O_3) with the chemiluminescence method.

[2] Estimated accuracy.

Detection techniques are the same as those described in Progress Report 3-Summary. See Section 2.1.1.2 for specific methods used in the Air Quality Studies.

2.1.1.3 Results

Analysis of the air quality parameters measured on Tract C-a indicates that with the exception of ozone and hydrocarbons, the mean values are in the expected low background ranges. Results of the analysis are discussed and tabulated in this section.

Table 2.1-2 presents a comparison of federal and state standards with measurements taken from 1 September 1975 through 31 November 1975 at the RBOSP sites. Both nonmethane hydrocarbon (NMHC) and particulates exceeded standards. The number of times that these measurements exceeded standards was analyzed, taking into consideration Table 2.1-1 which presents the lower limits of detectability and the accuracies of the analyzers used. When the lower limit of detectability of an analyzer is of similar magnitude as the regulatory standard, the analyzer will, at times, indicate higher values than the standard, although the standard may not be violated.

The conclusion was reached that some of the violations of the federal nonmethane hydrocarbon standard could have been related to instrument specifications because the combination of detection limit and accuracy is similar in magnitude to the standards value. Eleven nonmethane hydrocarbon values measured for the quarter violated the federal 3-hour maximum primary and secondary standards. This represents less than one percent of the available time in the quarter.

One particulate concentration observed during this quarter violated the federal 24-hour maximum primary and secondary standards and the state 24-hour maximum standards. However, the mean value for all sites for the quarter, if continued at the same rate, would not result in an annual mean higher than the federal of state annual particulates standard.

The state SO_2 24-hour maximum standard has been superseded by the new ambient air standards (Colorado Air Pollution Control Commission 1975, Colorado Air Quality Control Regulations and Ambient Air Quality Standards, Colorado Department of Health, Denver, Colorado) which establish a maximum allowable increment above the background concentrations.

Seasonal minimum, maximum, and mean values for all air quality parameters for fall are presented in Table 2.1-3.

Table 2.1-2. Comparison of Federal and State air quality standards to measurements made during Fall 1975, RBOSP.

Parameter	Standard		Time Interval	Type of Standard	No. of Times Exceeded During Quarter	Site 1 Max. Measured Value			Site 2 Max. Measured Value			Site 3 Max. Measured Value			Site 4 Max. Measured Value		
	µg/m³	ppm				µg/m³	ppm	Time	µg/m³	ppm	Time	µg/m³	ppm	Time	µg/m³	ppm	Time
CO	40,000	35	1 hr. max.	Primary and Secondary[1/]	0	2248	1.963	1000 10/23	—	—	—	5250	4.584	1100 9/1	—	—	—
CO	10,000	9	8 hr. max.	Primary and Secondary[1/]	0	1245	1.087	1600 10/23	—	—	—	4354	3.802	1100 9/1	—	—	—
Nonmethane Hydrocarbon	160	0.24	3 hr. max. (6-9am only)	Primary and Secondary[1/]	11	298	0.456	9/20	285	0.436	9/2	77	0.117	9/25	91	0.139	9/30
NO^2	100	0.05	Annual Arith. Mean	Primary and Secondary[1/]	NA	2[3/]	0.001[3/]	NA	—	—	—	0[3/]	0.000[3/]	NA	—	—	—
Ozone	160	0.08	1 hr. max.	Primary and Secondary[1/]	0	94	0.048	2300 9/2	—	—	—	106	0.054	1900 9/18	—	—	—
SO_2	365	0.14	24 hr max.	Primary and Secondary[1/]	0	10	0.004	2100 9/5	24	0.007	1700 10/17	18	0.007	11/1	81	0.031	1800 10/23
SO_2	80	0.03	Annual Arith. Mean	Primary[1/]	NA	8[3/]	0.003[3/]	NA	5[3/]	0.002[3/]	NA	5[3/]	0.002[3/]	NA	15[3/]	0.006[3/]	NA
SO_2	1300	0.5	3 hr. max.	Secondary[1/]	0	31	0.012	2200 11/27	175	0.067	2000 10/16	24	0.009	10/31	340	0.130	2200 10/22
Particulates	260	NA	24 hr. max.	Primary[1/]	1	43	NA	10/7	102	NA	10/7	137	NA	10/25	469	NA	10/7
Particulates	75	NA	Annual Geo. Mean	Primary[1/]	NA	6[4/]	NA	NA	11[4/]	NA	NA	21[4/]	NA	NA	11[4/]	NA	NA
Particulates	150	NA	24 hr. max.	Secondary[1/]	1	43	NA	10/7	102	NA	10/7	137	NA	10/25	469	NA	10/7
Particulates	60	NA	Annual Geo. Mean	Secondary[1/]	NA	6[4/]	NA	NA	16	NA	NA	18	NA	NA	12	NA	NA
Particulates	150[7/]	NA	24hr Max	State[2/]	1	33	NA	10/7	78	NA	10/7	105	NA	10/25	360	NA	10/7
Particulates	45[7/]	NA	Annual Arith. Mean	State[2/]	NA	9[3/]	NA	NA	17	NA	NA	26[3/]	NA	NA	34[3/]	NA	NA

Detection techniques are the same as those described in Progress Report 3-Summary. See Section 2.1.1.2 for specific methods used in the Air Quality Studies.

2.1.1.3 Results

Analysis of the air quality parameters measured on Tract C-a indicates that with the exception of ozone and hydrocarbons, the mean values are in the expected low background ranges. Results of the analysis are discussed and tabulated in this section.

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	$\mu g/m^3$	ppm				$\mu g/m^3$	ppm	Time	$\mu g/m^3$	ppm	Time	$\mu g/m^3$	ppm	Time	$\mu g/m^3$	ppm	Time
CO	40,000	35	1 hr. max.	Primary and Secondary1/	0	2248	1.963	1000 10/23	—	—	—	5250	4.584	1100 9/1	—	—	—
CO	10,000	9	8 hr. max.	Primary and Secondary1/	0	1245	1.087	1600 10/23	—	—	—	4354	3.802	1100 9/1	—	—	—
Nonmethane Hydrocarbon	160	0.24	3 hr. max. (6-9am only)	Primary and Secondary1/	11	298	0.456	9/20	285	0.436	9/2	77	0.117	9/25	91	0.139	9/30
NO^2	100	0.05	Annual Arith. Mean	Primary and Secondary1/	NA	2[3/]	0.001[3/]	NA	—	—	—	0[3/]	0.000[3/]	NA	—	—	—
Ozone	160	0.08	1 hr. max.	Primary and Secondary1/	0	94	0.048	2300 9/2	—	—	—	106	0.054	1900 9/18	—	—	—
SO_2	365	0.14	24 hr max.	Primary and Secondary1/	0	10	0.004	2100 9/5	24	0.007	1700 10/17	18	0.007	11/1	81	0.031	1800 10/23
SO_2	80	0.03	Annual Arith. Mean	Primary1/	NA	8[3/]	0.003[3/]	NA	5[3/]	0.002[3/]	NA	5[3/]	0.002[3/]	NA	15[3/]	0.006[3/]	NA
SO_2	1300	0.5	3 hr. max.	Secondary1/	0	31	0.012	2200 11/27	175	0.067	2000 10/16	24	0.009	10/31	340	0.130	2200 10/22
Particulates	260	NA	24 hr. max.	Primary1/	1	43	NA	10/7	102	NA	10/7	137	NA	10/25	469	NA	10/7
Particulates	75	NA	Annual Geo. Mean	Primary1/	NA	6[4/]	NA	NA	11[4/]	NA	NA	21[4/]	NA	NA	11[4/]	NA	NA
Particulates	150	NA	24 hr. max.	Secondary1/	1	43	NA	10/7	102	NA	10/7	137	NA	10/25	469	NA	10/7
Particulates	60	NA	Annual Geo. Mean	Secondary1/	NA	6[4/]	NA	NA	16	NA	NA	18	NA	NA	12	NA	NA
Particulates	150[7/]	NA	24hr Max	State2/	1	33	NA	10/7	78	NA	10/7	105	NA	10/25	360	NA	10/7
Particulates	45[7/]	NA	Annual Arith. Mean	State2/	NA	9[3/]	NA	NA	17	NA	NA	26[3/]	NA	NA	34[3/]	NA	NA

Table 2.1-2. Continued

1/ Environmental Protection Agency Regulations on national primary and secondary ambient air quality standards (40 CFR 50; 36 FR 22384, November 25, 1971: as amended by 38 FR 25678, September 14, 1973; 40 FR 7042, February 18, 1975).
2/ Ambient air standards for metropolitan Denver air quality control region, air quality control areas, and the State of Colorado; Adopted: September 10, 1970, Effective: December 17, 1970.
3/ Arithmetic mean of values measured during the quarter.
4/ Geometric mean of values measured during the quarter.
5/ All EPA standards are at reference conditions of 25
6/ Reference conditions of
7/ Measured at ambient temperature and pressure.
NA = Not Applicable.
____ = Not measured at this site.

Table 2.1-3 Air quality parameters, seasonal summary for Fall 1975, RBOSP

Parameter	Units	Minimum	Maximum	Arithmetic Mean
		SITE 1		
O_3	ppm	0.013	0.048	0.025
CO	ppm	0.005	1.963	0.632
NO	ppm	0.000	0.047	0.001
NO_x	ppm	0.000	0.076	0.002
CH_4	ppm	0.095	1.123	0.951
THC	ppm	0.870	1.358	1.043
H_2S	ppm	0.000	0.027	0.001
SO_2	ppm	0.002	0.027	0.003
Particulates	$\mu g/m^3$	< 0.06	43.35	6.21 1/
		SITE 2		
CH_4	ppm	0.166	1.180	0.975
THC	ppm	0.188	1.362	1.058
H_2S	ppm	0.000	0.011	0.002
SO_2	ppm	0.001	0.014	0.002
Particulates	$\mu g/m^3$	2.13	101.66	15.84 1/
		SITE 3		
O_3	ppm	0.004	0.054	0.027
CO	ppm	0.072	4.584	0.943
NO	ppm	0.000	0.012	0.001
NO_x	ppm	0.000	0.013	0.001
CH_4	ppm	0.781	1.290	1.050
THC	ppm	0.895	1.409	1.105
H_2S	ppm	0.000	0.012	0.002
SO_2	ppm	0.000	0.013	0.003
Particulates	$\mu g/m^3$	5.95	136.60	18.36 1/
		SITE 4		
CH_4	ppm	0.356	1.204	0.997
THC	ppm	0.523	1.238	1.033
H_2S	ppm	0.001	0.029	0.004
SO_2	ppm	0.002	0.046	0.006
Particulates	$\mu g/m^3$	0.31	469.28	12.08 1/

1/Geometric Mean

The seasonal mean values for CO, NO, NO_x, and SO_2 shown on Table 2.1-3 are similar in value to the lower limit of detectability of the analyzers. Levels of nonmethane hydrocarbons and ozone are similar in magnitude to the maximum levels specified by the regulatory standards. The levels of these compounds appear to be background and not associated with man's activity. The hydrocarbon (both methane and nonmethane) concentrations remain relatively constant throughout the day, while the ozone exhibits definite diurnal variations with a maximum at about noon and a minimum at about midnight. Intersite comparisons between the same parameters show good agreement.

Table 2.1-4 gives the particulate concentration for the quarter for each site. The large variation between samples and sites is expected because of considerable fugitive dust caused by activities on site and dust from the road. For example, Site 3 is not far from a well-traveled road, which may be the source of the high values obtained there.

Excessive amounts of particulates which exceeded federal secondary and state of Colorado air quality standards (150 $\mu g/m^3$) were occasionally measured on windy days.

Particle size data by concentration and particle size range are given in Table 2.1-5. These data show that a large portion of the particulate weight is made up of particles of 0 to 0.95 µm. The values indicated by $<0.06\ \mu g/m^3$ are less than the estimated concentration measurable by the measurement technique.

The results of particle trace element analysis on a particulate sample taken during the quarter are given in Table 2.1-6.

Table 2.1-4 Particulate concentration data for Fall 1975, values are presented in $\mu g/m^3$, RBOSP.

Month	Day	Year	Site 1	Site 2	Site 3	Site 4
September	1	1975	23.48	38.75	32.00	46.60
	4		14.48	38.69	38.44	38.57
	7		6.81	29.25	45.37	25.14
	10		21.83	36.11	42.18	49.72 1/
	13		≥13.92 2/	14.90	28.88	18.70
	16		11.83	22.56	26.85	12.63
	19		51.99	21.15	25.93	19.56
	22		11.96	12.57	36.30	11.22
	25		15.02	20.11	19.31	14.96
	28		10.60	23.85	26.98	16.49
October	1	1975	4.78	8.64	33.54	0.31
	4		16.00	35.13	25.57	24.95
	7		43.35	101.66	136.60	469.28
	10		12.14	30.84	41.08	35.74
	13		5.03	8.52	6.74	7.05
	16		22.62	15.02	13.67	19.74
	19		5.70	21.27	25.26	2.26
	22		8.25	65.66	73.57	72.16
	25		5.51	15.87	10.23	11.64
	28		0.30	10.48	7.35	26.24
	31		3.24	10.48	8.15	8.15
November	3	1975	< 0.06 3/	4.29	5.95	2.02
	6		4.29	12.81	13.06	9.87
	9		0.67	3.62	6.07	5.52
	12		6.32	13.43	7.54	2.15
	15		0.79	3.68	8.03	2.58
	18		1.96	23.97	32.50	17.23
	21		8.15	8.52	6.25	5.94
	24		9.93	2.13	8.89	5.08
	27		12.86	8.52	9.99	7.84
	30		4.72	21.52	6.62	6.81

1/Measurement

2/Small portion of corner was missing when weighed

3/Estimated accuracy of procedure

Table 2.1-5 Particulate concentration by equivalent aerodynamic diameter[1/] for Fall 1975, RBOSP.

Size Range (microns)	Particulate Concentration ($\mu g/m^3$)							
	9/4	9/28	10/10	10/22	10/28	11/3	11/15	11/27
7.2 - ∞	0.31	0.61	0.31	0.42	<0.06	<0.06	<0.06	<0.06
3.0 - 7.2	0.31	0.18	0.06	0.79	<0.06	<0.06	<0.06	0.61
1.5 - 3.0	<0.06	<0.06	0.31	0.55	<0.06	<0.06	<0.06	0.98
0.95 - 1.5	<0.06	<0.06	<0.06	0.61	0.18	<0.06	<0.06	0.73
0 - 0.95	10.18	10.42	11.83	7.66	0.12	<0.66	0.31	12.13

[1/] "Equivalent Aerodynamic Diameter" is defined as the size of a spherical particle of density 1 gm/cc, which has the same terminal settling velocity as the sampled particle.

Table 2.1-6.. High volume filter, analytical trace element results for Fall 1975, RBOSP.

Parameter	Concentration (ng/cm^2)	Parameter	Concentration (ng/cm^2)	Parameter	Concentration (ng/cm^2)	Parameter	Concentration (ng/cm^2)
Uranium	<0.18	Terbium	<0.10	Ruthenium	<0.10	Vanadium	11
Thorium	0.56	Gadolinium	<0.10	Molybdenum	<2.0	Titaniam	650
Bismuth	0.49	Europium	<0.10	Niobium	1.1	Scandium	0.42
Lead	12	Samarium	<0.10	Zirconium	5.8	Calcium	≈10,000
Thallium	<0.47	Neodymium	0.28	Yttrium	0.63	Potassium	≈6,000
Mercury	0.2	Praseodymium	0.73	Strontium	38	Chlorine	4.8
Gold	<0.10	Cerium	3.1	Rubidium	5.6	Sulfur	660
Platinum	<0.10	Lanthanum	0.78	Bromine	0.30	Phosphorus	800
Iridium	<0.10	Barium	34	Selenium	1.5	Silicon	≈83,000
Osmium	<0.10	Cesium	<0.10	Arsenic	4.0	Aluminum	≈14,000
Rhenium	Internal Standard	Iodine	0.26	Germanium	<0.10	Magnesium	≈4,200
Tungsten	<0.36	Tellurium	<0.10	Gallium	1.8	Sodium	≈2,000
Tantalum	2.3	Antimony	0.14	Zinc	11	Flourine	340
Hafnium	<0.10	Tin	0.66	Copper	170	Oxygen	NR*
Lutecium	<0.10	Indium	Internal Standard	Nickel	7.7	Nitrogen	NR*
Ytterbium	<0.10	Cadmium	<0.10	Cobalt	0.84	Carbon	NR*
Thallium	<0.10	Silver	0.47	Iron	≈3,400	Boron	NR*
Erbium	<0.10	Palladium	<0.10	Manganese	91	Beryllium	<0.19
Holmium	<0.10	Rhodium	<0.10	Chromium	21	Lithium	2.7
Dysprosium	<0.10						

*NR - Not reported

2.2 METEOROLOGY

The meteorological studies are designed to at least meet and, in some cases, exceed environmental lease stipulations.

The RBOSP meteorological data acquisition system is integrated into the network described in Section 2.1. It includes instrument towers at Sites 1, 2, 3, and 4. Data transmission from the remote sites and recording methods are similar to those utilized in the air quality studies, i.e., hard copy reports are provided hourly, and continuous analog records are made for each parameter.

The Central Station is located at Site 1, which has a 60-m meteorological tower. Wind speed, wind direction, air temperature and relative humidity are measured at the 10-m level. Ambient temperature, wind speed, and wind direction are measured at the 30- and 60-m levels, and the temperature differences between the 10- and 60-m levels are recorded. Additionally, precipitation and solar radiation are monitored at ground level at Site 1.

All meteorological parameters are measured continuously. The data are averaged during the last 15 minutes of each hour and entered into the computer file.

The following parameters are not part of the automatic data acquisition system, but are monitored routinely or seasonally at Site 1:

- Evaporation rate
- Snow depth and water content
- Particulates
- Visibility

At each of remote sites 2, 3, and 4 there is a 10-m meteorological tower. Wind speed, wind direction, and ambient air temperature are measured at the 10-m level.

A seasonal upper air study measuring winds and temperatures to an elevation of 13,000 feet above MSL is scheduled over Tract C-a for five quarters of the program. These studies, performed by manually tracking pilot balloons with a theodolite and aircraft-mounted temperature sensors, provide basic information on the mean mixing layer height above Tract C-a.

Tracer diffusion studies designed to track dispersion of the tracer material in the lower atmosphere to evaluate modeling predictions and lead to a better understanding of terrain effects will be conducted. Ambient noise level measurements will also be taken.

All the data obtained are used to define the baseline atmospheric conditions and for application in the appropriate diffusion models used to predict the effects of shale oil operations on ambient air quality.

The baseline meteorological program is established at two lower atmospheric levels, referred to in this report as lower air studies and upper air studies. The lower air studies include data obtained at the four station networks; the upper air studies involve obtaining data on the winds aloft and vertical temperature profiles. Upper air studies are performed on a seasonal basis. Tracer studies are performed during the baseline study period concurrently with upper air wind and temperature samplings. Studies which provide useful information, but do not fall into these categories are: precipitation, evaporation, solar radiation, noise, and visibility (discussed under Miscellaneous, Section 2.2.3).

The Fall 1975 quarter (season), as used in this section is defined as September 1, 1975 through November 30, 1975.

2.2.1 Lower Air Studies

Lower air studies refer to the meteorological data acquired from the four station ground networks and include wind speed, direction, and air temperature at 10-m above the surface at all four monitoring sites. Relative humidity at 10-m, and wind speed, wind direction, and air temperature at 30- and 60-m above the surface at the main monitoring site are also included.

2.2.1.1 Objectives

No change has occurred since Progress Report 4-Summary. See Section 2.2.1.1 in Progress Report 4-Summary for specific objectives of the meteorological lower air studies.

2.2.1.2 Methods

No change has occurred since Progress Report 2-Summary. See Section 2.2.1.2 in Progress Report 2-Summary for specific methods used in the meteorological lower air studies.

2.2.1.3 Results

The 1975 fall season summaries of the minimum, maximum, and mean values of the meteorological parameters measured at each site are presented in Table 2.2-1. The composite hour, as illustrated in Figures 2.2-1 through 2.2-6, is the mean of the data taken during a particular hour of the day for all days of the month. A composite day defines the minimum, maximum, and mean values for 24 composite hours of a month. The minimum and maximum listed are the individual hourly averages which are greater than or less than all other hourly averages.

Wind at Sites 1 and 2 (10-m level) were predominantly from the southwest during Fall 1975. The mean wind speeds were 7.76 and 8.63 mph, respectively. Although Sites 1 and 2 are at about the same elevation (7,400 feet above MSL); the local terrain at Site 2 is relatively flatter than at Site 1. The Site 2 monitoring location is the highest point within a radius of approximately 1 km. The 10-m level of the main meteorological tower at Site 1 is approximately 50 m lower than the elevation of several knolls within several hundred meters. The increased terrain influence at Site 1 is probably responsible for the lower mean wind speed.

Table 2.2-1. Meteorological parameters, seasonal summary for Fall 1975, RBOSP.

Parameter	Units	Minimum	Maximum	Mean
SITE 1				
Wind Speed (10 m)	mph	0.59	28.53	7.76
Wind Speed (30 m)	mph	0.57	36.16	9.03
Wind Speed (60 m)	mph	0.56	40.64	10.68
Wind Direction Sigma (10 m)	degrees	0.96	45.00	11.99
Air Temperature (10 m)	C	-15.80	24.83	7.50
Air Temperature (30 m)	C	-15.90	23.60	7.08
Temperature Difference (60 to 10 m)	C	-4.31	2.09	0.03
Relative Humidity (10 m)	%	13.00	91.20	33.62
SITE 2				
Wind Speed (10 m)	mph	0.10	34.85	8.63
Air Temperature (10 m)	C	-16.00	24.45	7.20
SITE 3				
Wind Speed (10 m)	mph	0.58	22.30	6.73
Air Temperature (10 m)	C	-21.00	27.02	5.46
SITE 4				
Wind Speed (10 m)	mph	0.54	29.56	5.76
Air Temperature (10 m)	C	-25.90	28.35	4.85

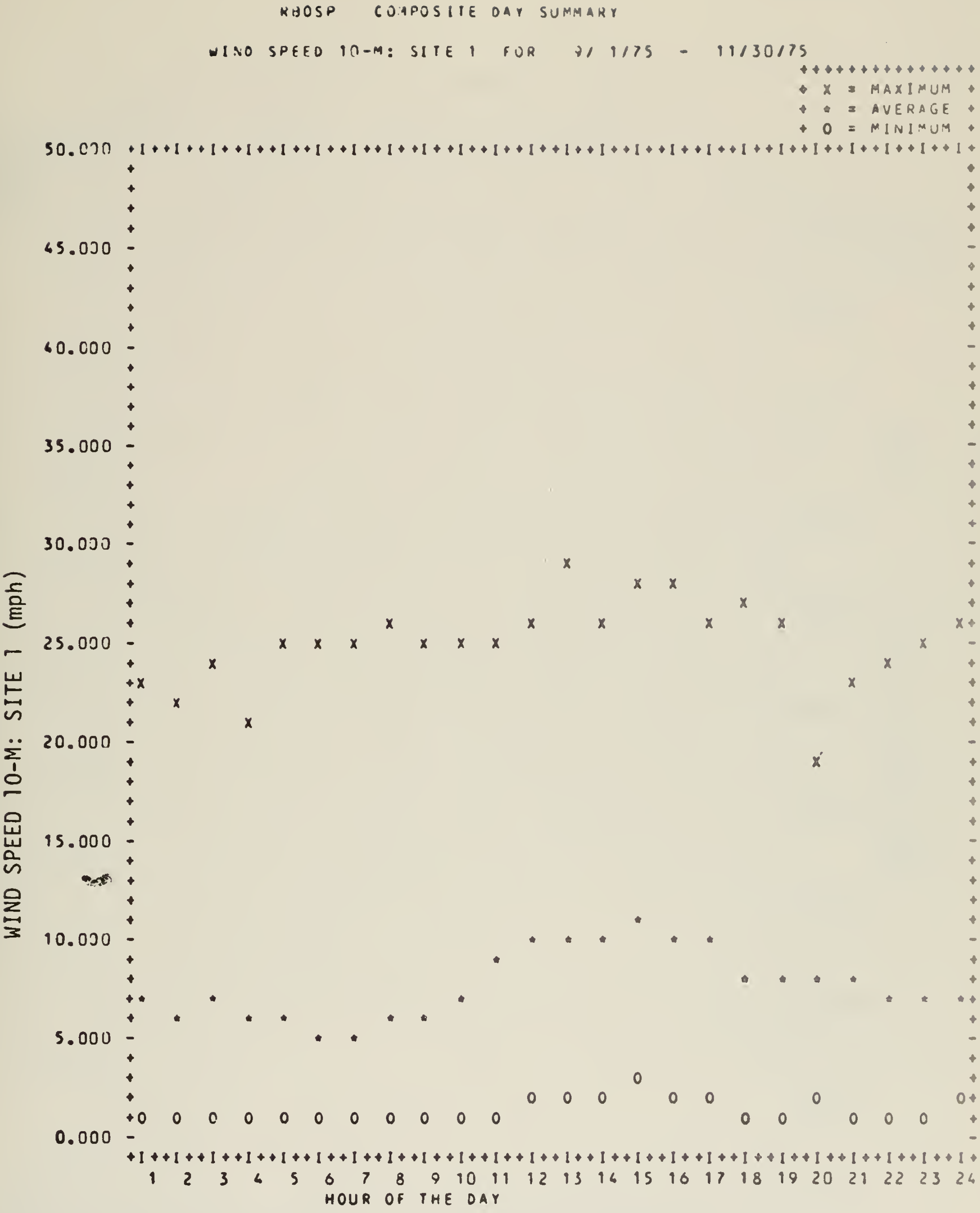

Figure 2.2-1. Wind speed, 10-m level (minimum, maximum, and mean by hour of the day) for Fall 1975 at Site 1, RBOSP.

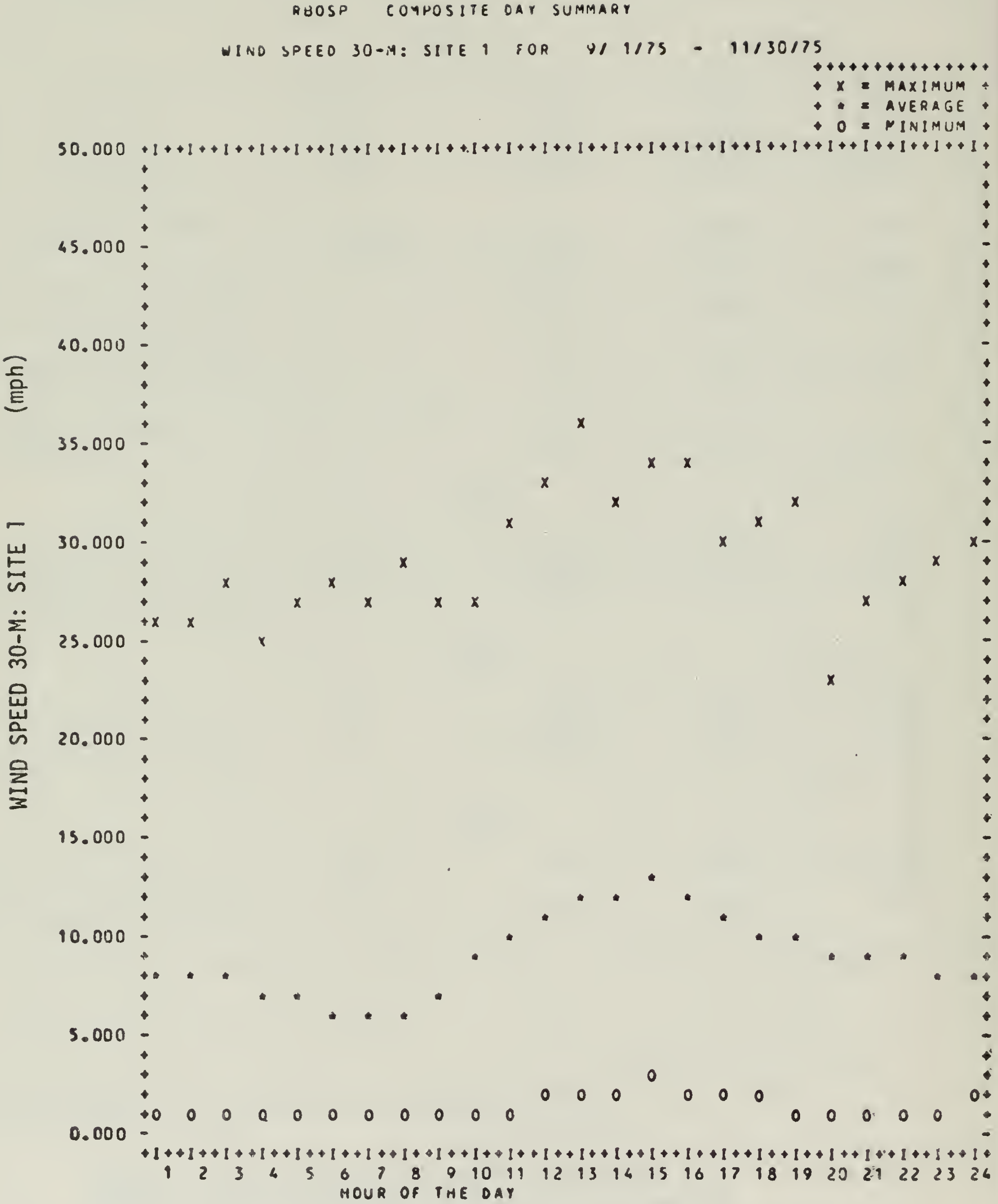

Figure 2.2-2. Wind speed, 30-m level (minimum, maximum, and mean by hour of the day) for Fall 1975 at Site 1, RBOSP.

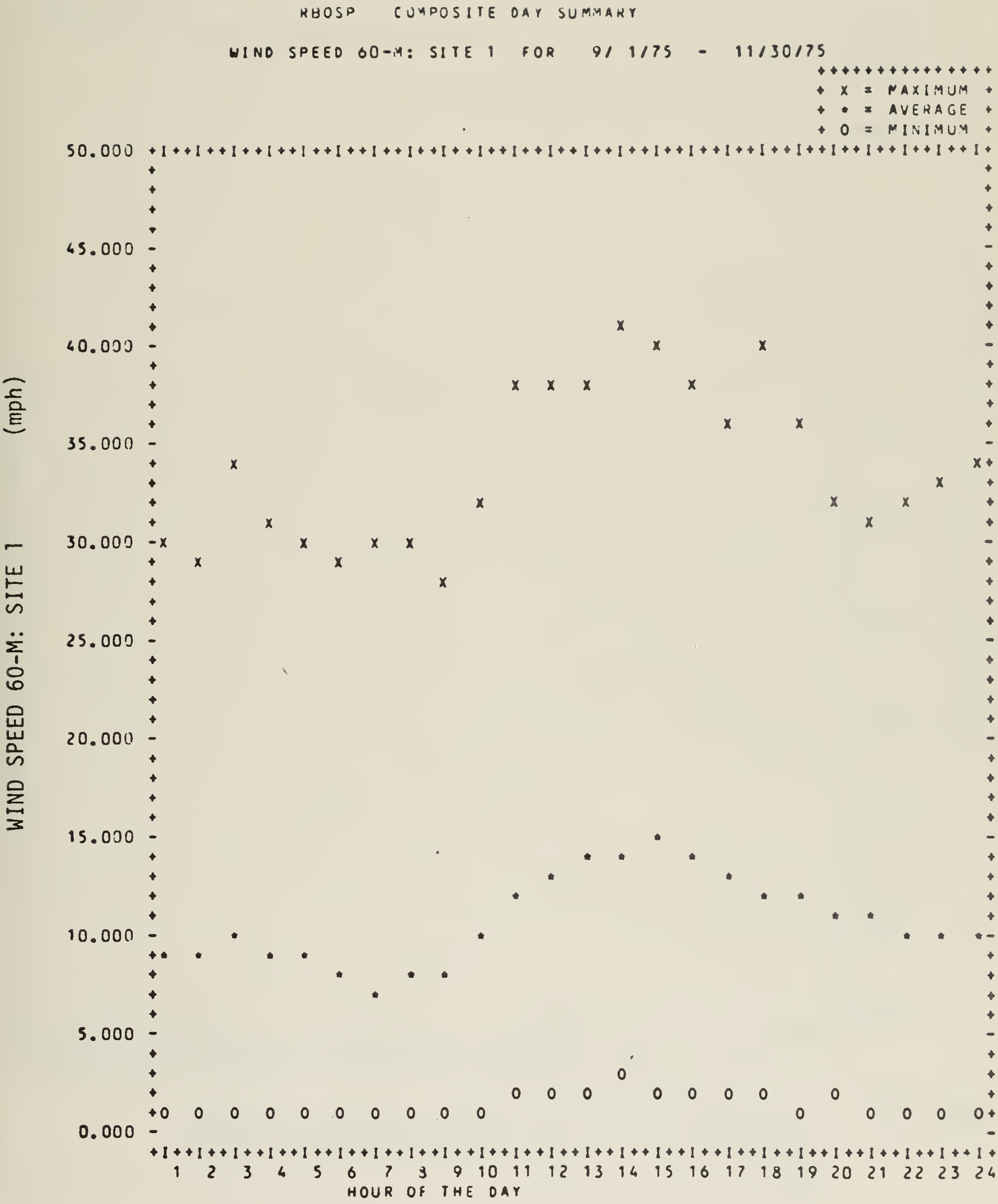

Figure 2.2-3. Wind speed, 60-m level (minimum, maximum, and mean by hour of the day) for Fall 1975 at Site 1, RBOSP.

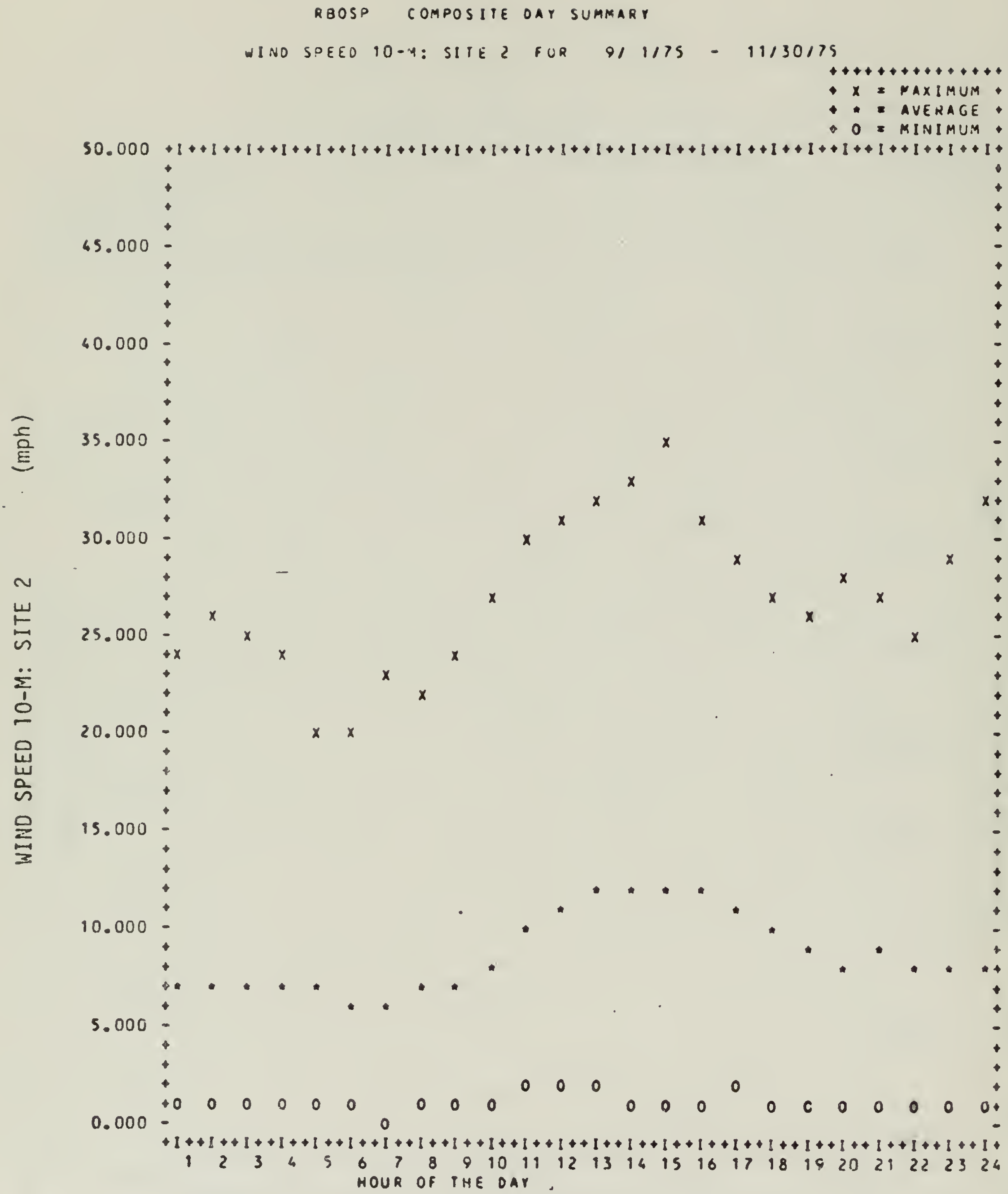

Figure 2.2-4. Wind speed, 10-m level (minimum, maximum, and mean by hour of the day) for Fall 1975 at Site 2, RBOSP.

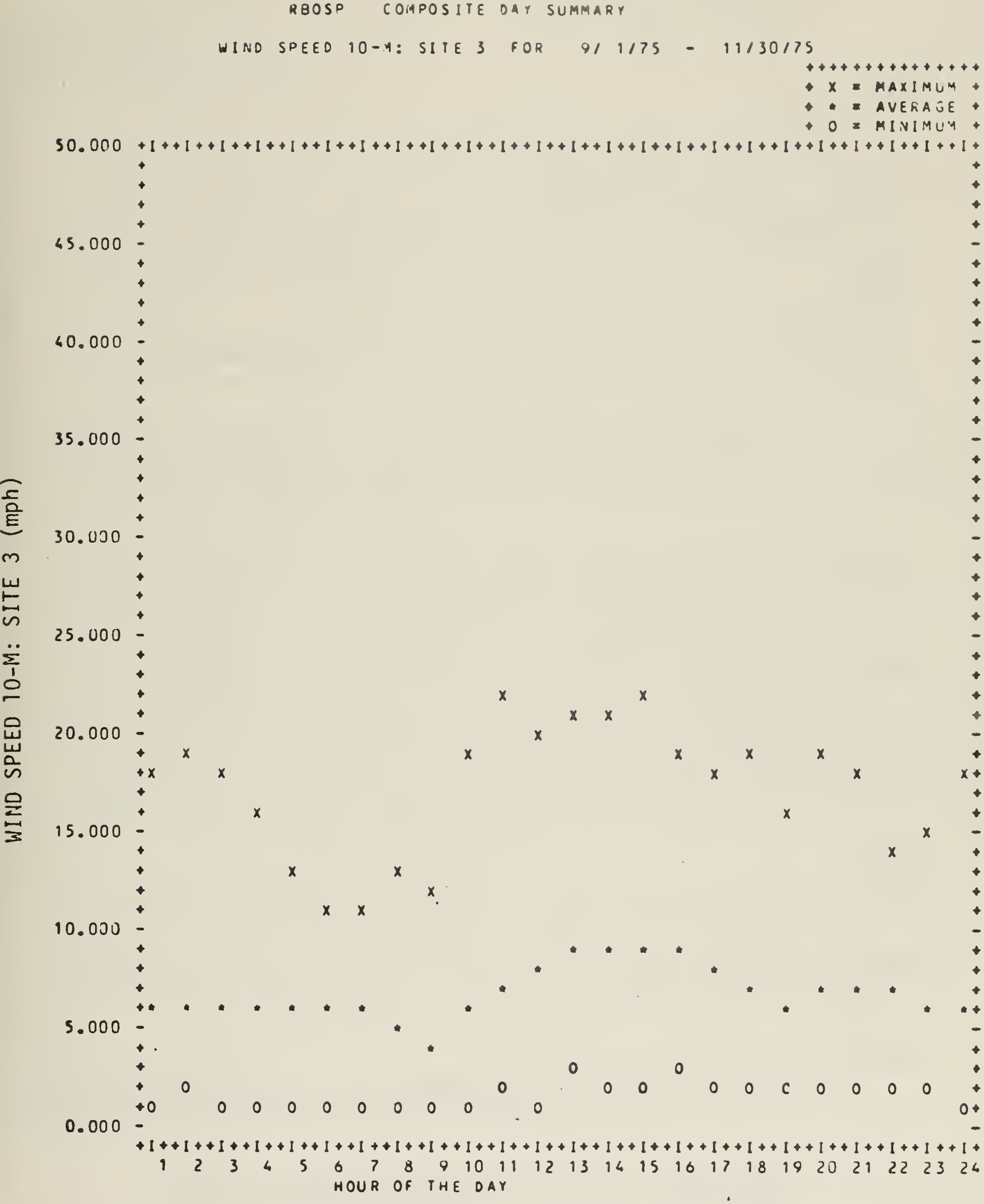

Figure 2.2-5. Wind speed, 10-m level (minimum, maximum, and mean by hour of the day) for Fall 1975 at Site 3, RBOSP.

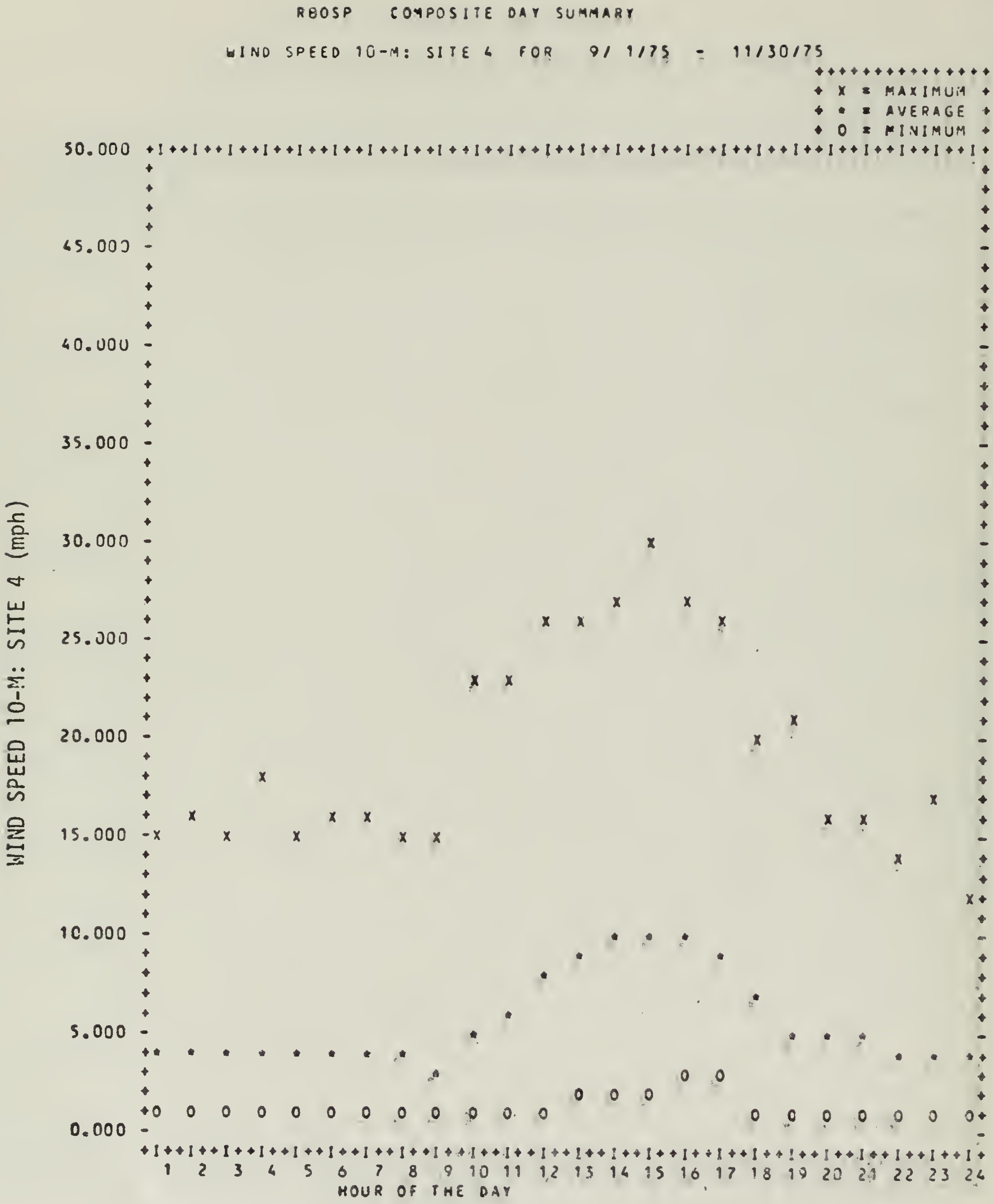

Figure 2.2-6. Wind speed, 10-m level (minimum, maximum, and mean by hour of the day) for Fall 1975 at Site 4, RBOSP.

Mean wind speeds at Sites 3 and 4 for the Fall 1975 period were 6.73 and 5.76 mph, respectively. Sites 3 and 4, below plateau levels, are situated in the approximate centers of Corral Gulch and Yellow Creek Gulch at elevations of 6,570 and 6,280 feet above MSL. Corral Gulch is oriented in a west to east direction. Yellow Creek Gulch is oriented in a south-southwest to north-northwest direction.

The diurnal variation of mean wind speed is shown in Figures 2.2-1 to 2.2-6 for each site. Mean wind speeds average 4 to 7 mph higher during daytime hours than nighttime hours with Sites 2 and 4 showing the larger variation. The 60-m level has about a 7 mph higher wind speed during the day than at night. During June, there was a double peak for the 60-m mean wind speed, one occurring at about 0300 and one during the daylight hours.

The diurnal variation of the wind direction sigma at the 10-m level, Site 1 is shown in Figure 2.2-7. Several maximum peaks occurred in the morning hours.

Wind rose data for Fall 1975 are presented for all four monitoring stations in Figures 2.2-8 through 2.2-11. The percent of occurrence of each wind class can be obtained from the number scale on each wind rose plot.

Wind rose data (10-m level) from Sites 1 and 2 are comparable. The reduced frequency of occurrence of southwest winds relative to south-southwest and west-southwest winds is probably caused by the influence from a small knoll about 200 m southwest of Site 1. Extreme terrain-induced wind channeling effects exist at Sites 3 and 4. Winds at Site 3 are predominantly from the west, which is in agreement with the westerly course of Corral Gulch. The predominant winds at Site 4 are from the southwest, corresponding closely to the orientation of Stake Springs Draw and Yellow Creek. In addition to the terrain-induced channeling of the gradient winds at Sites 3 and 4, valley drainage flows probably contribute significantly to the direction of winds.

The term gradient wind is used here to describe wind flows resulting from a pressure difference between two points at the same elevation. While the term valley drainage flow is used to describe the winds resulting from radiative cooling of the rear surface layers of air which produces a subsiding, down-slope flow.

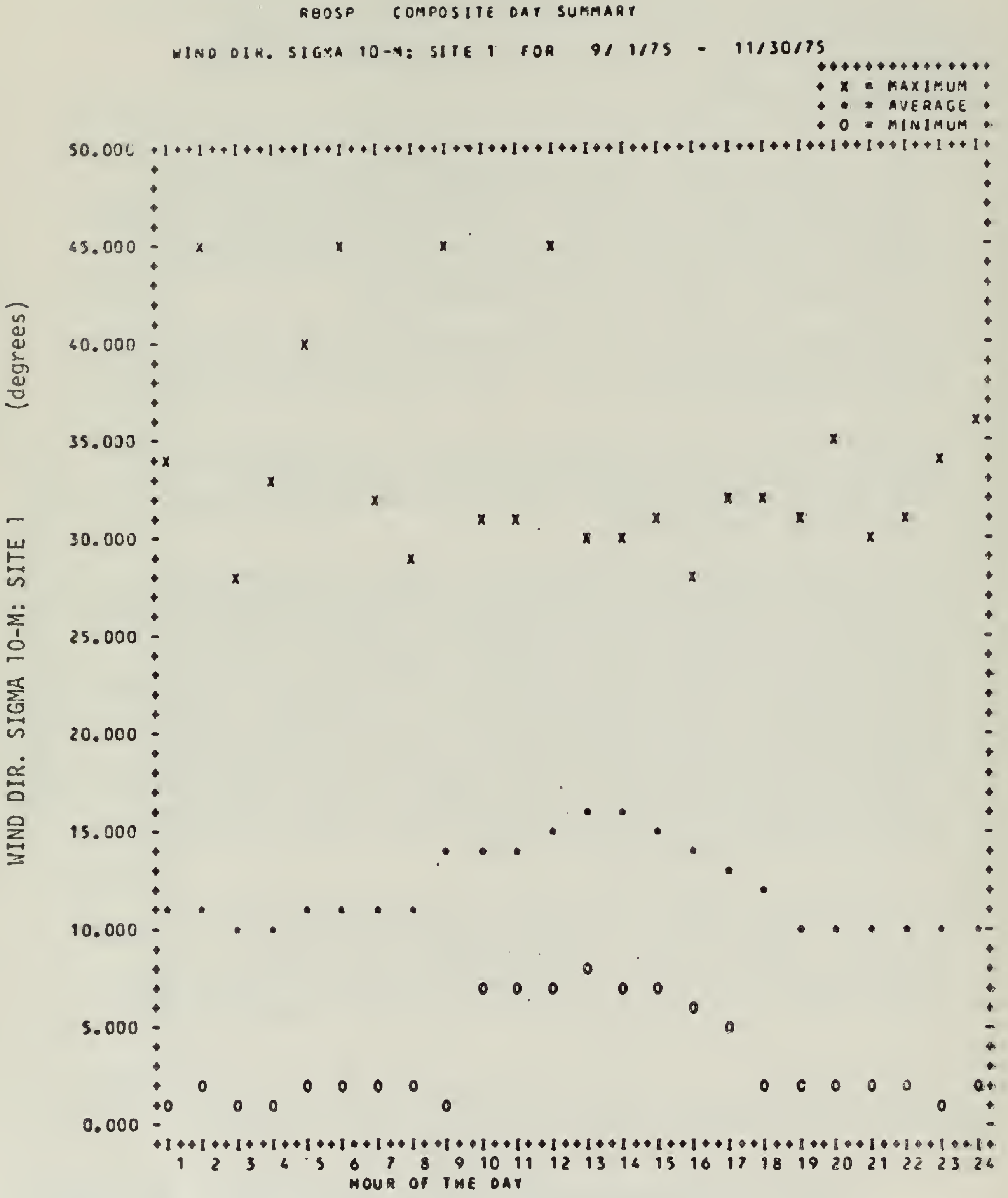

Figure 2.2-7. Wind direction sigma, 10-m level (minimum, maximum, and mean by hour of the day) for Fall 1975 at Site 1, RBOSP.

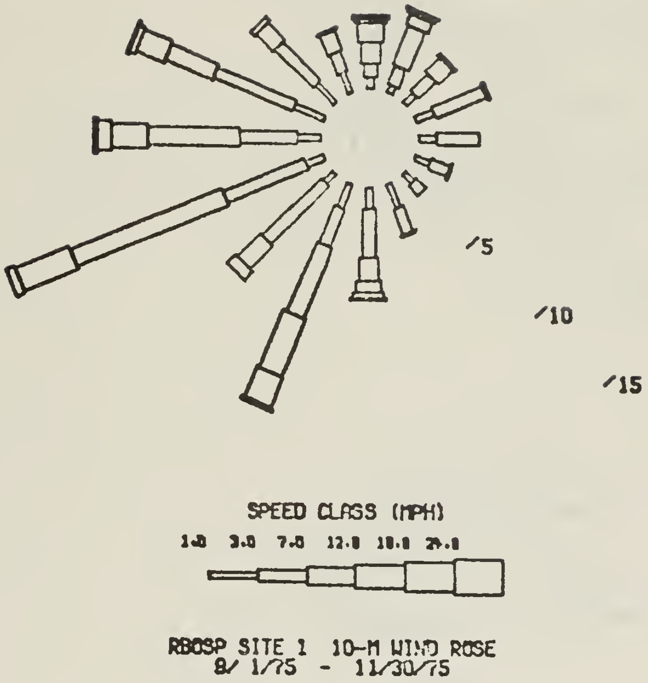

Figure 2.2-8. Fall 1975 wind rose from the 10-m level at Site 1, RBOSP.

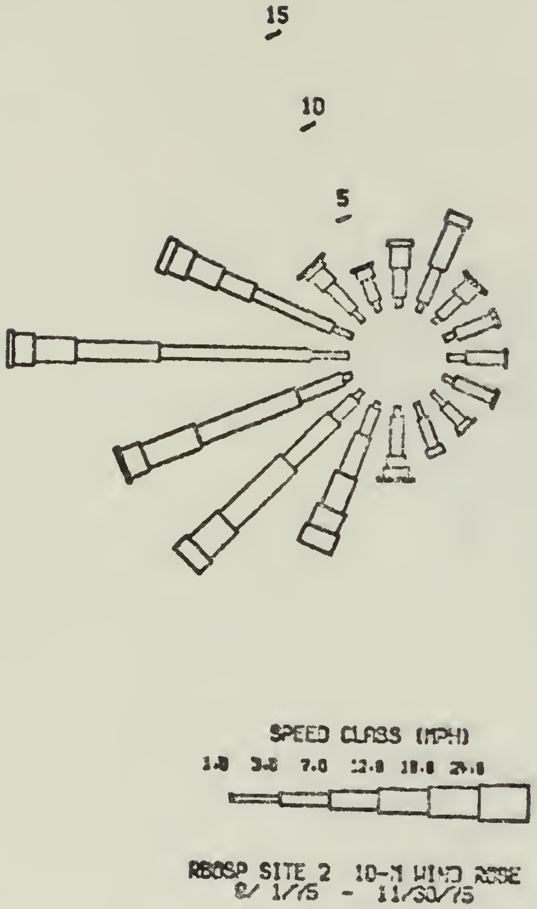

Figure 2.2-9. Fall 1975 wind rose from the 10-m level at Site 2, RBOSP.

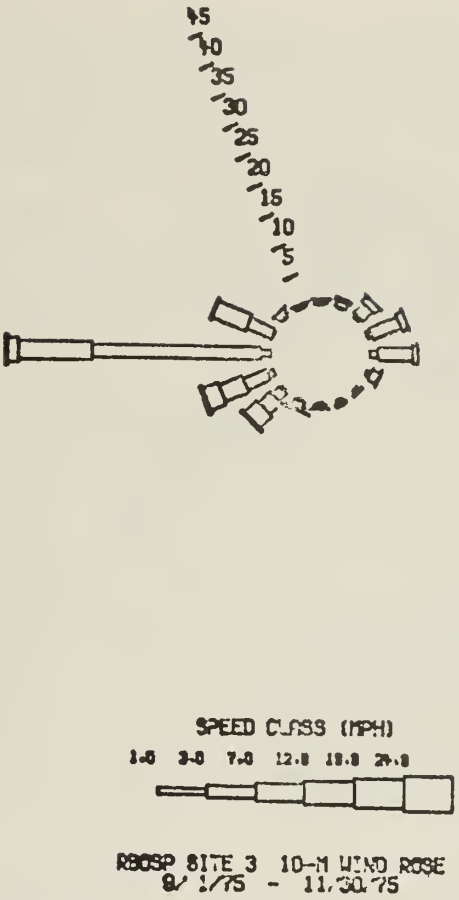

Figure 2.2-10. Fall 1975 wind rose from the 10-m level at Site 3, RBOSP.

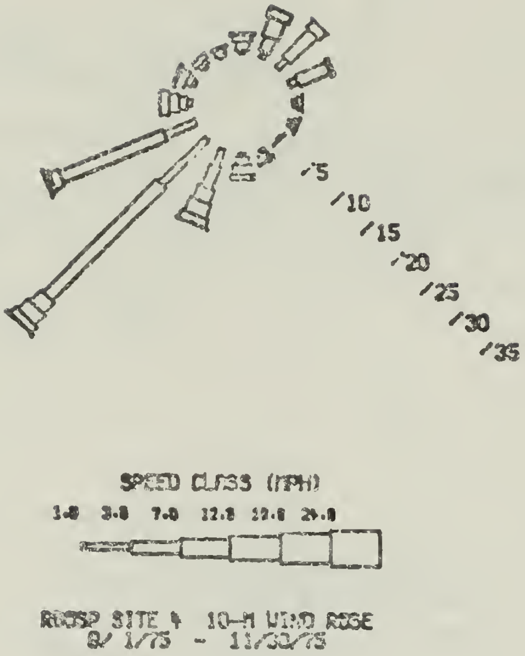

Figure 2.2-11. Fall 1975 wind rose from the 10-m level at Site 4, RBOSP.

A least squares fit to the mean seasonal wind speed as a function of height at the 60-m tower (Site 1) was done to investigate the applicability of the logarithmic wind profiles:

$$\bar{u} = \frac{u^*}{K} \ln \left(\frac{Z}{Z_o}\right)$$

where Z_o is the roughness parameter, K is the von Karman constant, and u^* is the friction velocity. The seasonal data fit the logarithmic wind profile to a high degree of confidence (coefficient of determination = r^2 = 0.96) with u_*/K = 1.58 mph and Z_o = 8.2 cm. Z = height above ground (in meters).

The minimum, maximum, and mean values of air temperature for each of the four sites and temperature difference at Site 1 as a function of the hour of the day for the fall season are plotted in Figures 2.2-12 through 2.2-17.

The valley sites (3 and 4) have a much larger diurnal temperature variation than the plateau sites (1 and 2). The intensity of the cold portion of the composite days at Sites 3 and 4, in relation to that at Sites 1 and 2, is much greater. This is probably because of valley drainage flows. The composite day air temperature data for Sites 3 and 4 indicate that more cold air accumulates at Site 4 than at Site 3. The 200-foot elevation difference and the Stake Spring Draw air flow, as well as the Corral Gulch air flow draining into the Yellow Creek Gulch, contribute to this intensity difference.

Although there is a substantial difference in the diurnal variation among all sites, the average temperatures over the season agree well between sites.

Atmospheric stability conditions were determined from temperature difference measurements made between the 10-m and the 60-m level on the main meteorological tower at Site 1. Figure 2.2-17 presents the minimum, maximum, and mean composite day temperature differences as a function of the time of day for the fall season 1975. The data indicate that the mean surface inversion is relatively weak (about a -0.4 C difference in temperature) during the interval from 2000 hours MST in the evening until 0700 hours MST the following morning. When the break-up of the mean surface inversion occurs, atmospheric stability becomes significantly unstable. The intensities of the most stable inversions are more intense than those of the most unstable conditions.

The percent of occurrence of the modified Pasquill stability categories for fall 1975 and associated mean wind speeds are presented in Table 2.2-2. Stability categories were calculated according to the following criteria:

Stability Index	Temperature change (C) with heights per 100 m
A	$\Delta T < -1.9$
B	$-1.9 \leq \Delta T < -1.7$
C	$-1.7 \leq \Delta T < -1.5$
D	$-1.5 \leq \Delta T < -0.5$
E	$-0.5 \leq \Delta T < 1.5$
F	$1.5 \leq \Delta T < 4.0$
G	$4.0 \leq \Delta T$

The wind speeds, as a function of stability category, show a definite relationship. Category A has the highest average wind speed and E has the lowest. The slightly stable Category E occurred most often during nighttime hours with F and G occurring in early morning around 0600.

Figure 2.2-18 graphically presents the minimum, maximum, and mean composite day relative humidities as a function of hour of day for Fall 1975. The relative humidity data were taken at the 10-m level at Site 1. There was a significant decrease (14%) in the average relative humidity at sunrise. The effect is probably due to the surface heating of the air. This composite daily transition period occurs over 4 hours. The decrease may also arise from the increased thermally generated turbulent mixing caused by the reversal of the average lapse rate from slightly stable to slightly unstable and the increased surface temperature.

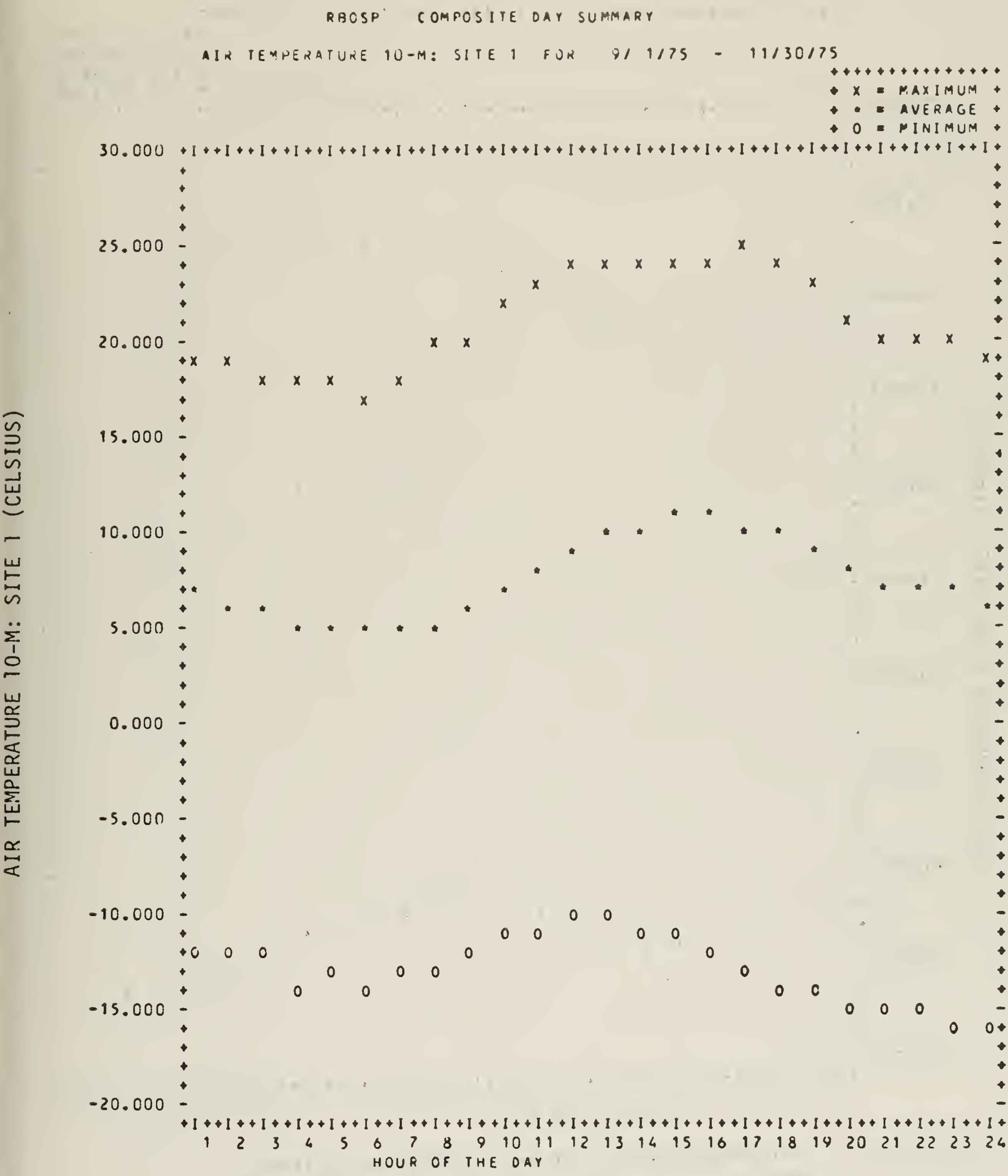

Figure 2.2-12. Air temperature, 10-m level (minimum, maximum and mean by hour of the day) for Fall 1975 at Site 1, RBOSP.

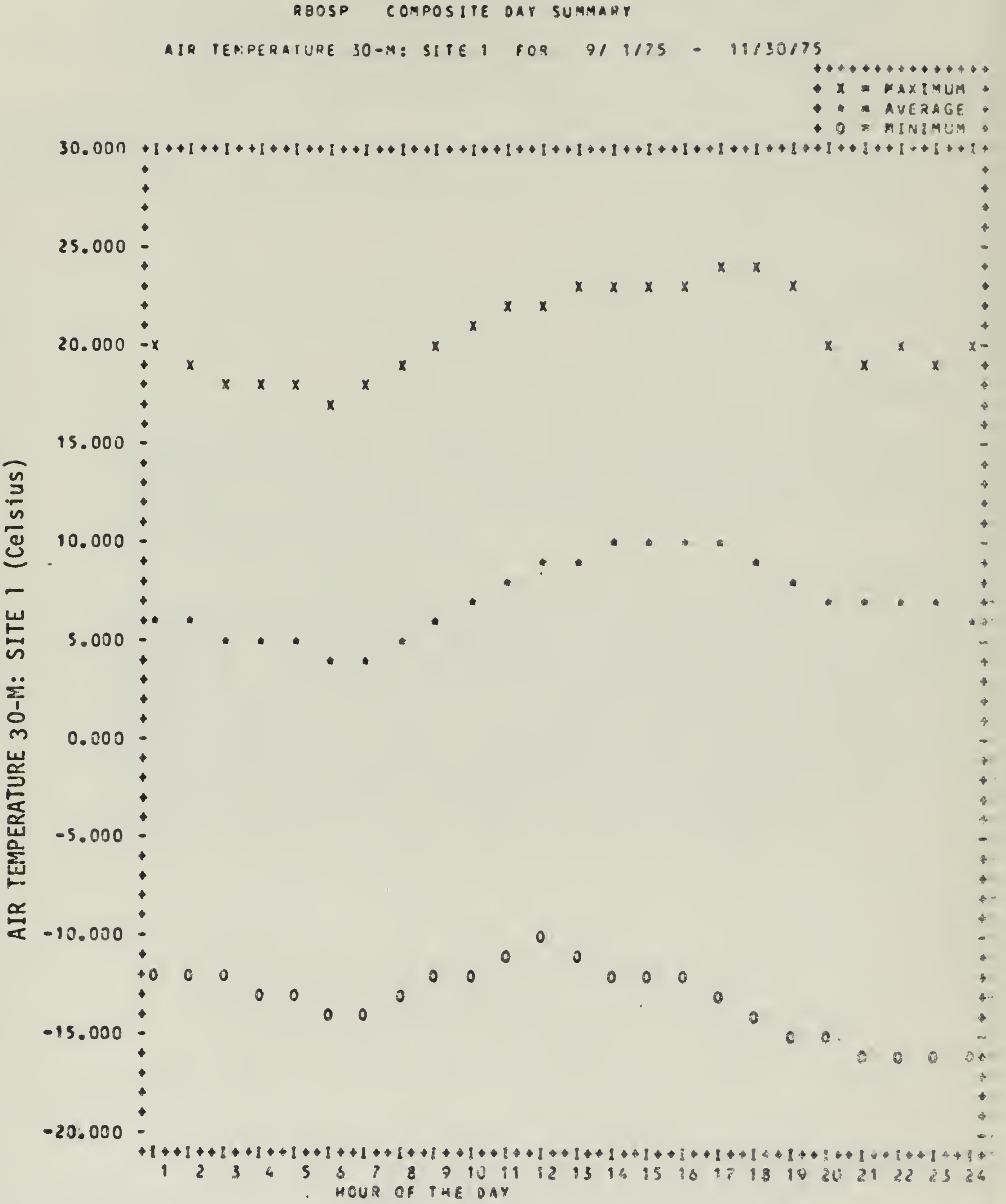

Figure 2.2-13. Air temperature, 30-m level (minimum, maximum, and mean by hour of the day) for Fall 1975 at Site 1, RBOSP.

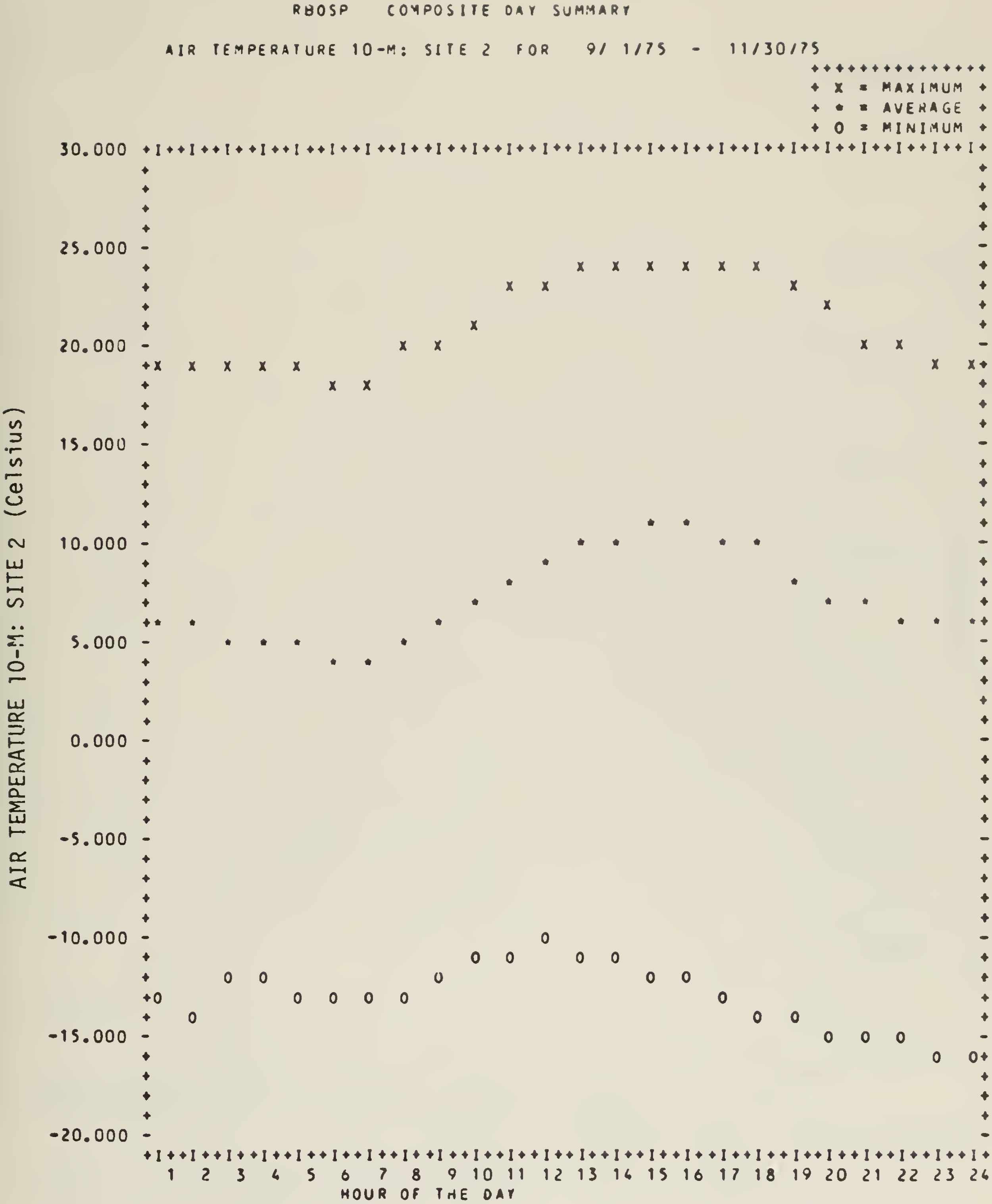

Figure 2.2-14 Air temperature, 10-m level (minimum, maximum, and mean by hour of the day) for Fall 1975 at Site 2, RBOSP.

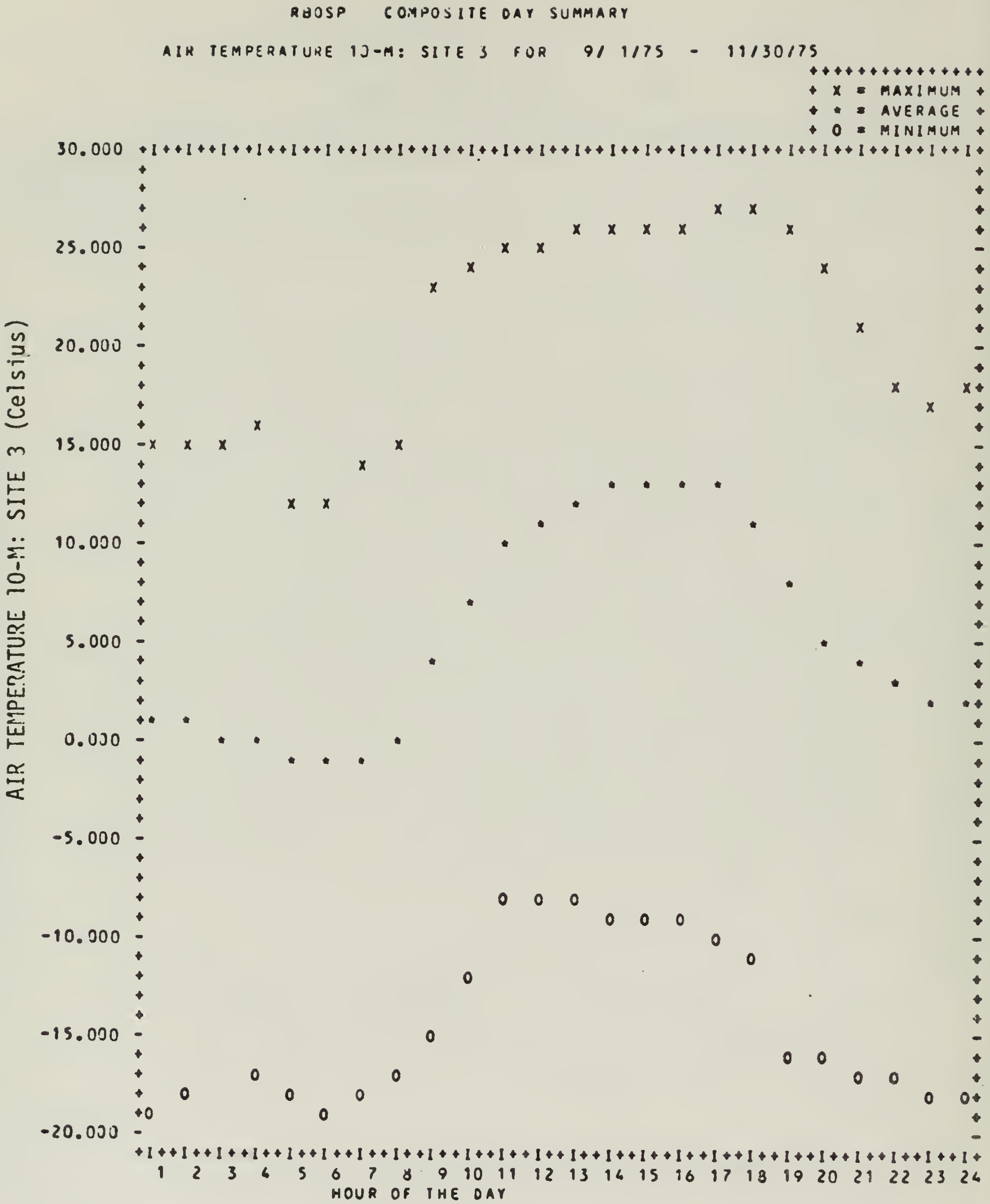

Figure 2.2-15. Air temperature, 10-m level (minimum, maximum, and mean by hour of the day) for Fall 1975 at Site 3, RBOSP.

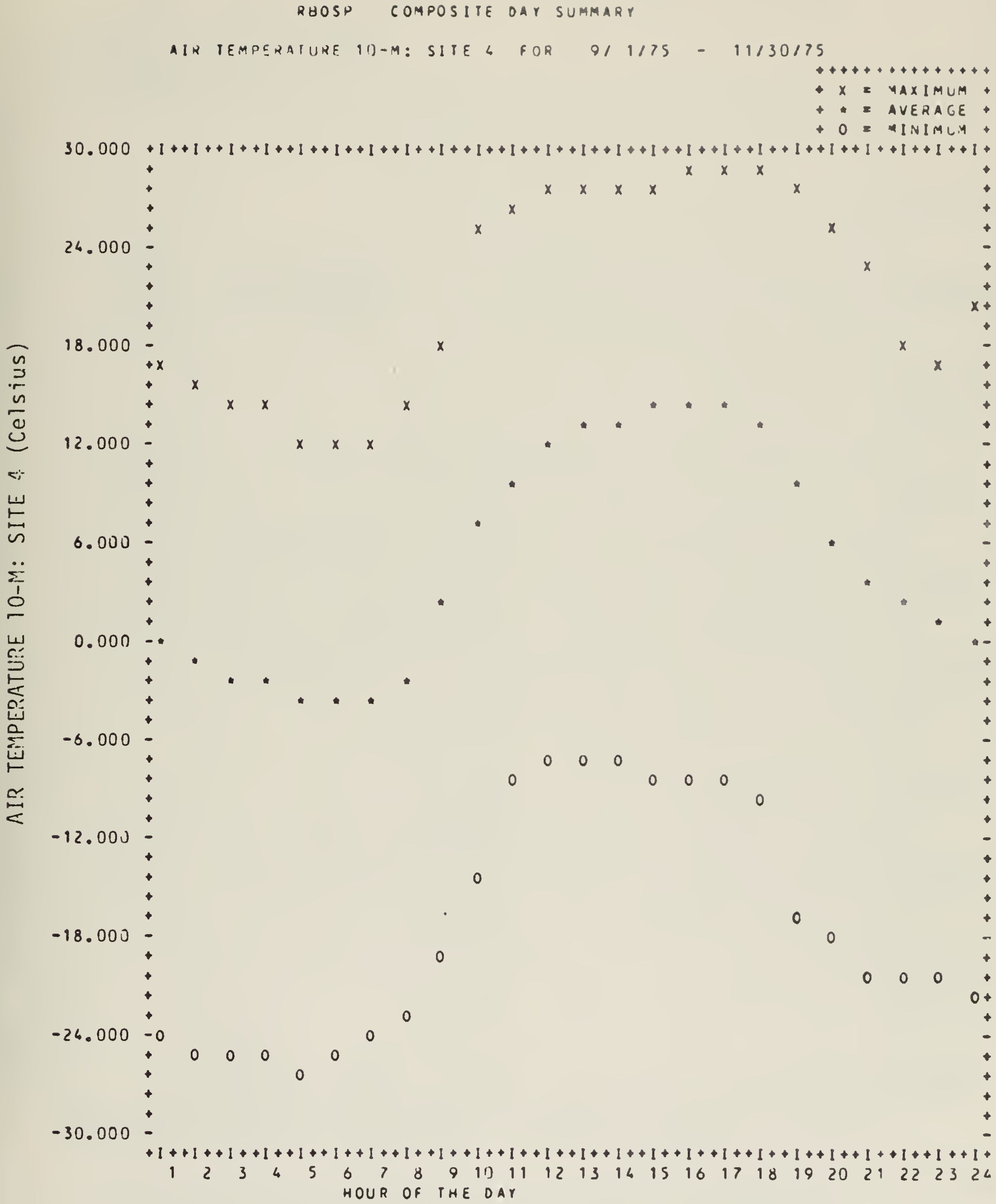

Figure 2.2-16. Air temperature, 10-m level (minimum, maximum, and mean by hour of the day) for Fall 1975 at Site 4, RBOSP.

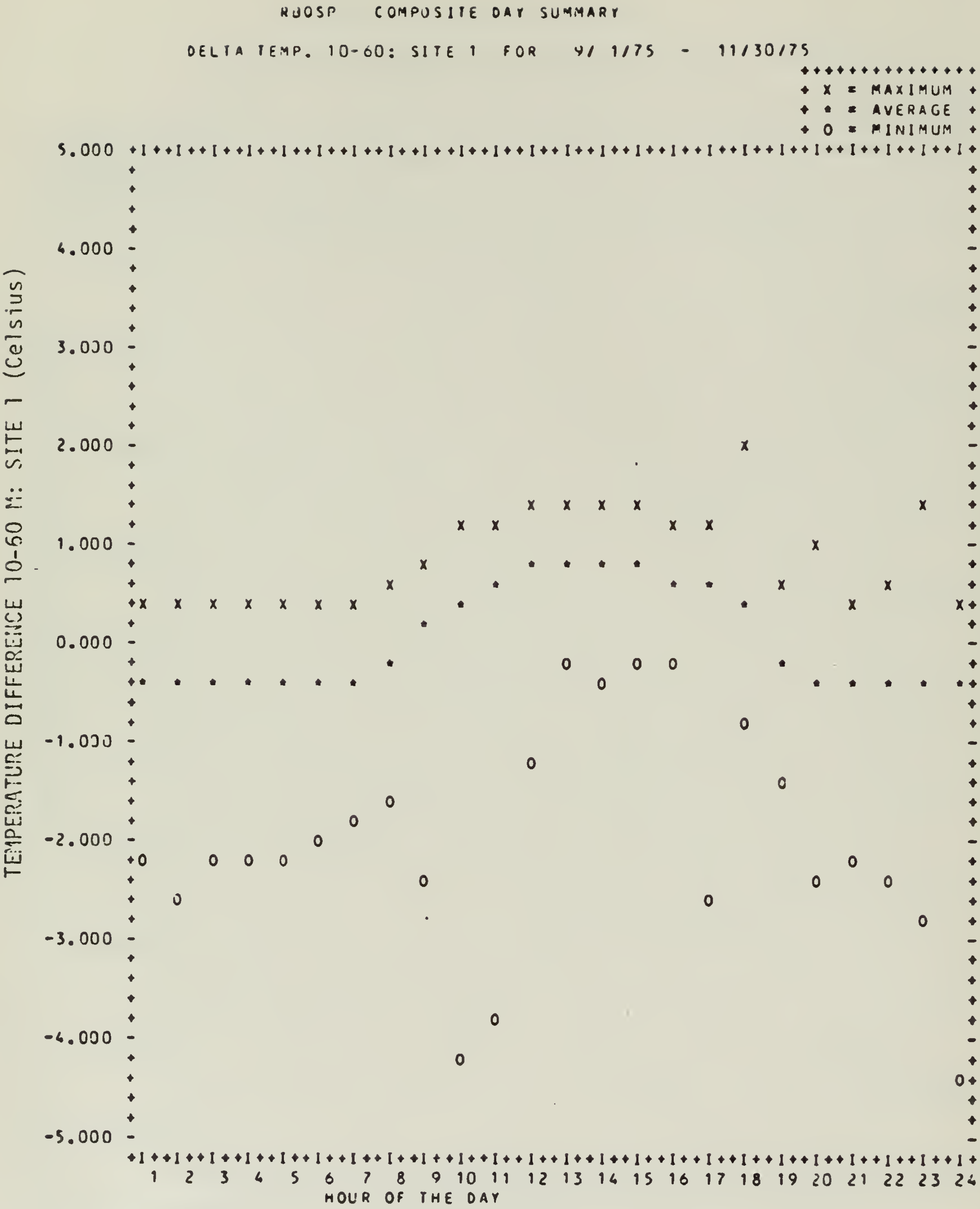

Figure 2.2-17. Temperature difference between 10-m and 60-m levels (minimum, maximum, and mean by hour of the day) for Fall 1975 at Site 1, RBCSP.

Table 2.2-2. Percent of occurrence of the Pasquill stability classes at Site 1. Stability category determined from the temperature difference between the 10- and 60-m levels during the Fall 1975, RBOSP.

Stability Classification	Pasquill Categories	Temperature Change with Height (C/100 m)	Percent of Occurrence	Mean Wind Speed (mph)
Extremely Unstable	A	Less than -1.9	5.43	12.59
Moderately Unstable	B	-1.9 to -1.7	4.18	10.84
Slightly Unstable	C	-1.7 to -1.5	5.24	8.73
Neutral	D	-1.5 to -0.5	28.31	6.32
Slightly Stable	E	-0.5 to 1.5	43.76	6.27
Moderately Stable	F	1.5 to 4.0	11.83	6.80
Extremely Stable	G	Greater than 4.0	1.25	7.77

SOURCE: David H. Slade, Editor, Meteorology and Atomic Energy Nat. Tech. Serv. TID-24190, pp. 102-103, 1971.

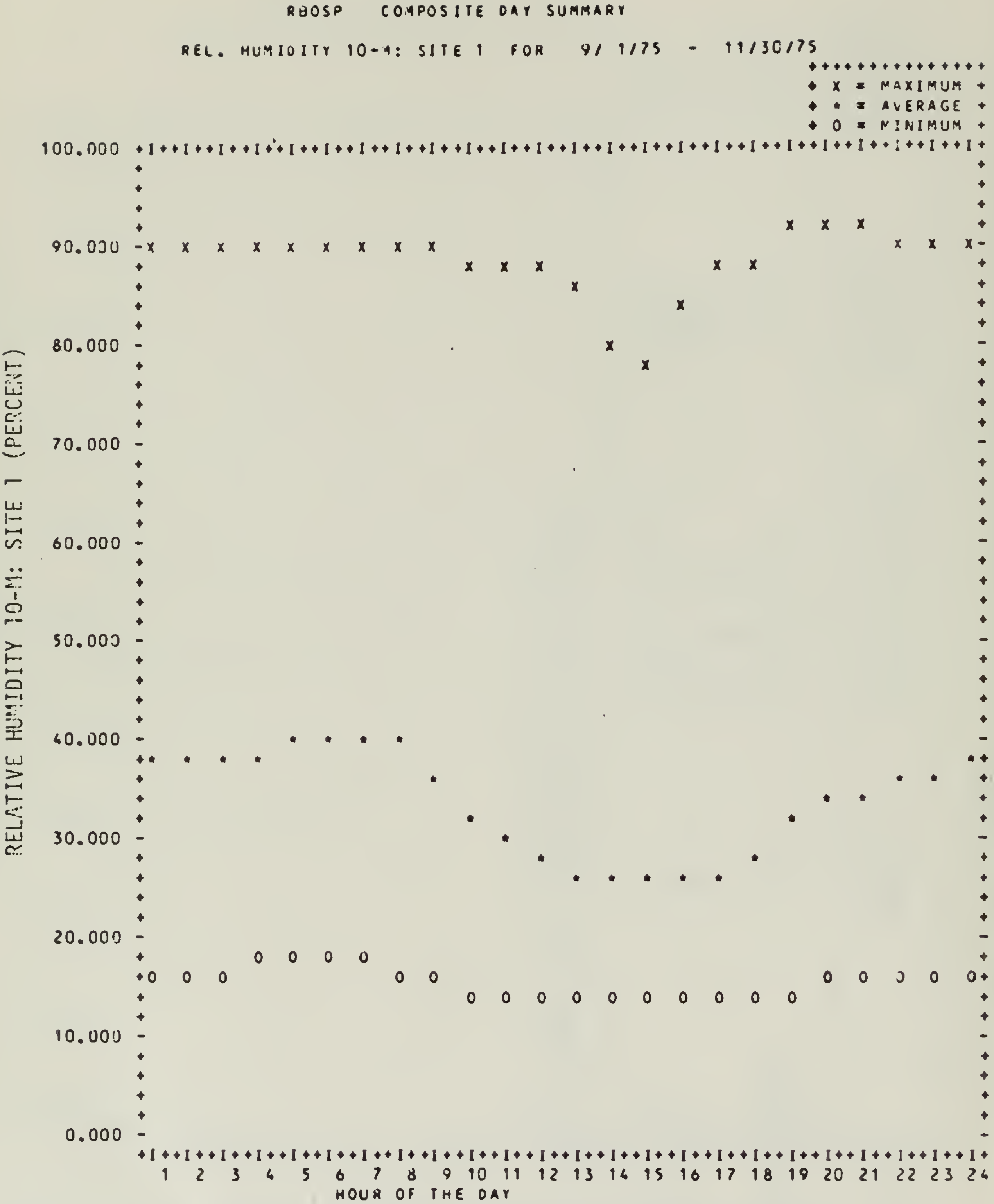

Figure 2.2-18. Relative humidity, 10-m level (minimum, maximum, and mean by hour of the day) for Fall 1975 at Site 1, RBOSP.

2.2.2 Upper Air Studies

2.2.2.1 Objectives

No change has occurred since Progress Report 4-Summary. See Section 2.2.2.1 in Progress Report 4-Summary for specific objectives for the upper air studies.

2.2.2.2 Methods

No change has occurred since Progress Report 4-Summary. See Section 2.2.2.2. in Progress Report 2-Summary for specific methods used in the temperature profile measurements.

2.2.2.3 Results

An upper air study was not performed during this quarter. The remaining upper air study is scheduled in the future.

2.2.3 Miscellaneous

The meteorological parameters grouped into this category are precipitation, evaporation, solar radiation, noise, visibility, snow course, and tracer studies. All these parameters, except precipitation, tracer studies and evaporation, are measured only at Site 1. Evaporation measurement is made at Site 3 because of water availability. The evaporation rate and visibility are not monitored continuously, but are recorded on a routine basis.

2.2.3.1 Precipitation Measurements

2.2.3.1.1 Objectives

No change has occurred since Progress Report 2-Summary. See Section 2.2.3.1.1 in Progress Report 2-Summary for specific methods used in the precipitation measurements.

2.2.3.1.2 Methods

No change has occurred since Progress Report 2-Summary. See Section 2.2.3.1.2 in Progress Report 2-Summary for specific methods used in the precipitation measurements.

2.2.3.1.3 Results

The precipitation data summary for Fall 1975 is presented in Table 2.2-3. The total and daily amounts of precipitation are shown for each site. Maximum total precipitation for 1 day was 0.45 inch at Site 4 on 22 October 1975.

Site 4 registered the largest total precipitation (1.76 inches for the Fall 1975 season.

Table 2.2- 3. Precipitation data for Fall 1975, RBOSP. (Values are presented in inches of water.)

Date	Site 1 Total	Site 2 Total	Site 3 Total	Site 4 Total
9/10/75	0.01	----	----	0.07
9/13/75	---	0.01	---	---
9/14/75	---	---	0.03	0.02
9/15/75	---	0.03	---	---
9/16/75	---	0.10	---	---
9/17/75	---	0.02	---	0.02
9/18/75	---	0.01	---	---
9/21/75	---	0.01	---	---
9/26/75	---	---	---	0.02
September Total	0.01	0.18	0.03	0.13
10/7/75	0.01	---	0.02	0.28
10/9/75	---	0.02	---	---
10/10/75	---	0.01	---	---
10/12/75	---	---	---	0.01
10/13/75	0.01	---	0.01	---
10/16/75	---	0.20	---	---
10/17/75	---	0.01	---	---
10/22/75	0.01	---	0.16	0.45
10/23/75	0.02	---	0.20	0.29
10/27/75	---	---	0.01	0.01
10/30/75	0.01	---	0.03	0.05
10/31/75	---	---	0.06	0.18
October Total	0.06	0.24	0.49	1.17
11/8/75	---	---	0.04	0.07
11/9/75	---	---	0.06	0.02
11/10/75	---	---	0.03	0.04
11/19/75	0.01	0.01	0.05	0.03
11/25/75	---	---	0.04	0.08
11/26/75	0.01	---	0.01	---
11/28/75	0.03	---	0.16	0.22
11/29/75	---	---	0.03	---
November Total	0.05	0.01	0.41	0.46
Fall Total	0.12	0.43	0.93	1.76

2.2.3.2 Evaporation Measurements

2.2.3.2.1 Objectives

No change has occurred since Progress Report 2-Summary. See Section 2.2.3.2.1 in Progress Report 2-Summary for specific objectives of the evaporation measurements.

2.2.3.2.2 Methods

No change has occurred since Progress Report 2-Summary. See Section 2.2.3.2.2 in Progress Report 2-Summary for specific methods used in the evaporation measurements.

2.2.3.2.3 Results

Data for the fall season are presented in Table 2.2-4. Measurements were discontinued after the 18 October 1975 reading due to repeated icing. The highest evaporation rate recorded was 0.024 g/cm^2/hour. This occurred during the week ending 9 September. The minimum evaporation rate was 0.013 g/cm^2/hour during the measurement period ending 18 October 1975.

The evaporation rates for the quarter basically decreased as the quarter progressed.

2.2.3.3 Solar Radiation Measurement

2.2.3.3.1 Objectives

No change has occurred since Progress Report 2-Summary. See Section 2.2.3.3.1 in Progress Report 2-Summary for specific objectives of the solar radiation measurements.

2.2.3.3.2 Methods

No change has occurred since Progress Report 2-Summary. See Section 2.2.3.3.2 in Progress Report 2-Summary for specific methods used in the solar radiation measurements.

2.2.3.3.3 Results

The minimum, maximum, and mean composite day solar radiation measurements as a function of hour of the day for fall 1975, are graphically presented in Figure 2.2-19. Solar radiation data were taken at ground level at Site 1. The hourly means follow a close approximation to a sine curve. The seasonal and hourly minimum, maximum, and mean values of the solar radiation are presented in Table 2.2-5.

Table 2.2-4. Evaporation data summary for Fall 1975, RBOSP.

End Date of Measurement Period	Time of Measurement Hours (MST)	Precipitation Since Last Reading (in)	Maximum Temperature Since Last Reading (C)	Minimum Temperature Since Last Reading (C)	Water Required to Fill Pan (in)	Evaporation Rate (g/cm^2/hr)
9/7/75	0935	0.00	27.0	5.0	1.80	0.024
9/13/75	1315	0.00	22.0	5.0	1.25	0.022
9/20/75	1437	0.03	23.0	3.5	1.05	0.016
9/27/75	1810	0.00	20.0	3.0	1.23	0.018
10/4/75	1219	0.00	19.0	3.0	1.31	0.021
10/11/75	1300	0.02	21.5	1.5	0.96	0.014
10/18/75	1132	0.01	23.0	1.5	0.72	0.013 1/

1/Evaporation measurements discontinued with this measurement due to observed icing during the next sampling period.

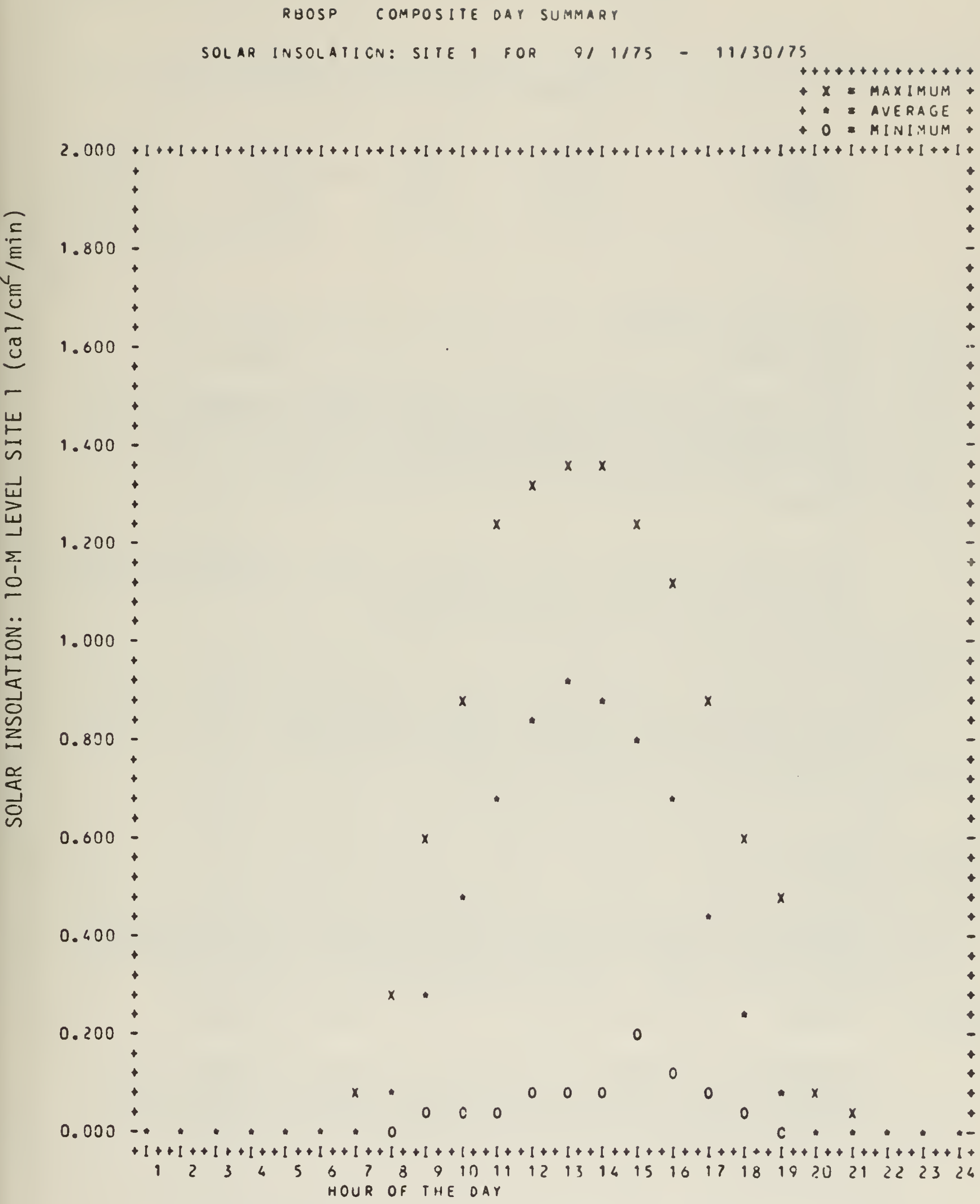

Figure 2.2-19. Solar Insolation (minimum, maximum, and mean by hour of the day) for Fall 1975 at Site 1, RBOSP.

Table 2.2-5. Solar radiation, seasonal and monthly summary for fall 1975, values are in Langleys or cal/cm^2/min, RBOSP.

	September	October	November	Fall 1975
Minimum	0.00	0.00	0.00	0.00
Maximum	1.34	1.17	0.93	1.34
Mean	0.35	0.28	0.18	0.27

2.2.3.4 Noise Measurements

2.2.3.4.1 Objectives

No change has occurred since Progress Report 2-Summary. See Section 2.2.3.4.1 in Progress Report 2-Summary for specific objectives of the noise measurements.

2.2.3.4.2 Methods

No change has occurred since Progress Report 2-Summary. See Section 2.2.3.4.2 in Progress Report 2-Summary for specific methods used in the noise measurements.

2.2.3.4.3 Results

Noise level field measurements were completed in this quarter. Data reduction and analysis were not initiated.

2.2.3.5 (a) Visibility Measurements (on Tract)

2.2.3.5.1 (a) Objectives

No change has occurred since Progress Report 2-Summary. See Section 2.2.3.5.1 in Progress Report 2-Summary for specific objectives of the visibility measurements.

2.2.3.5.2 (a) Methods

No change has occurred since Progress Report 2-Summary. See Section 2.2.3.5.2 in Progress Report 2-Summary for specific methods used in the noise measurements.

2.2.3.5.3 (a) Results

During fall 1975, visibility ranged from 8 to 150 miles for each day that data were recorded. The 8 mile visibility occurred on 13 October and 27 November (Tables 2.2-6 through 2.2-8).

2.2.3.5 (b) Visibility Measurements (Piceance Creek Basin Area)

2.2.3.5.1 (b) Objectives

The objectives of this visibility program (a cooperative study for RBOSP and the C-b Shale Oil Project) are to document the visibility in the area of the Piceance Creek Basin and identify trends or variations in visibility which may be evident during this year-long monitoring program. The results of this program will provide baseline visibility data against which future data may be compared and with which concurrent meteorological data may be incorporated for further evaluation and consideration.

2.2.3.5.2 (b) Methods

The method employed in the documentation of visibility incorporates the technique of photographic photometry to measure the attenuation of light by atmospheric scattering. Photographic photometry employs photographic film as the recording medium. The collection of visibility data in the Piceance Creek Basin area is accomplished from a point approximately 8 miles southwest of Piceance Creek on a ridge between Hunter Creek and Dry Gulch. Data are collected by photographing several objects, such as mountains or ridges, in each of four views which scan the horizon from the north-northwest to the east-northeast (Figure 2.2-20). These views were chosen to ensure that any directional variation in visibility which might occur could be evaluated. The use of at least two objects in each view enables the calculations of a visual range under a variety of visibility conditions. (Note: Visual range is a mathematically defineable quantity capable of being measured; visibility, when used, is a subjective term).

Black and white film is used to photograph the objects in each view at prescribed hours every 6th day. In addition color slides are taken concurrently to pictorially record the sky and weather conditions in each view during the hours of photography. Pertinent visibility information is recorded each hour in a Site Log by the photographer. Quality assurance procedures are employed to assure consistency and reliability of procedures and data.

Table 2.2-6. Visibility data for September 1975, RBOSP.

Date of Observation	Time of Observation Hours (MST)	Precipitation in Prior 24 Hours (Inches)	Sector Visibility N	E	S	W	Prevailing Visibility	Comments
9/1/75	1145	0	150	150	150	150	150	Estimated cloud coverage 20%.
9/4/75	1045	0	150	150	150	150	150	Estimated cloud coverage <1%. Light northeasterly breeze.
9/7/75	1630	0	100	100	100	100	100	Estimated cloud coverage 90%. Overcast with light southeasterly breeze.
9/10/75	0910	0	150	150	150	150	150	Estimated cloud coverage 25%.
9/13/75	1330	0	>80	>80	>80	>80	>80	Estimated cloud coverage 95%. Thundershowers in vicinity.
9/16/75	0810	0	150	150	150	150	150	Estimated cloud coverage 15%.
9/19/75	0830	0	150	150	150	150	150	No clouds visible.
9/22/75	1000	0	100	100	100	100	100	No clouds visible. Light northeasterly breeze.
9/25/75	1430	0	150	150	150	150	150	Estimated cloud coverage <1%.
9/28/75	0930	0	150	150	150	150	150	No clouds visible.

Table 2.2-7. Visibility data for October 1975, RBOSP.

Date of Observation	Time of Observation Hours (MST)	Precipitation in Prior 24 Hours (Inches)	Sector Visibility				Prevailing Visibility	Comments
			N	E	S	W		
10/1/75	1600	0	150	150	150	150	150	No clouds visible.
10/4/75	1000	0	150	150	150	150	150	Estimated cloud coverage 20%.
10/7/75	1130	0	60	60	60	60	60	Estimated cloud coverage 40%. Strong winds from the south, gusts to 50 mph.
10/10/75	0845	0	150	150	150	150	150	Estimated cloud coverage 10%.
10/13/75	1400	0.01	50	50	8	8	8	Estimated cloud coverage 80%. Snow showers in the area.
10/16/75	0845	0	150	150	150	150	150	Estimated cloud coverage 20%.
10/22/75	1400	0	80	80	80	80	80	Estimated cloud coverage 65%. Gusty south-westerly winds.
10/19/75	1700	0	> 60	> 60	> 60	> 60	> 60	Estimated cloud coverage 5%.
10/25/75	0820	0	150	150	150	150	150	Estimated cloud coverage 60%.

Table 2.2-7. Visibility data for October 1975, RBOSP (Continued).

Date of Observation	Time of Observation Hours (MST)	Precipitation in Prior 24 Hours (Inches)	Sector Visibility N	E	S	W	Prevailing Visibility	Comments
10/28/75	1315	0	>100	>100	>100	>100	>100	Estimated cloud coverage 1%. Noticed fog at Site 4.
10/31/75	1205	0	100	100	100	100	100	Estimated cloud coverage 100%. Light rain.

Table 2.2-8 . Visibility data for November 1975, RBOSP.

Date of Observation	Time of Observation Hours (MST)	Precipitation in Prior 24 Hours (Inches)	Sector Visibility				Prevailing Visibility	Comments
			N	E	S	W		
11/3/75	1100	0	>100	>100	>100	>100	>100	Estimated cloud coverage 80%.
11/6/75	1630	0	150	150	150	150	150	Estimated cloud coverage 1%.
11/9/75	0945	0	100	100	100	100	100	Estimated cloud coverage 97%.
11/12/75	1150	0	150	150	150	150	150	Estimated cloud coverage <1%.
11/15/75	1430	0	>100	>100	>100	>100	>100	Estimated cloud coverage 25%.
11/18/75	1400	0	150	150	150	150	150	Estimated cloud coverage 95%.
11/21/75	1530	0	80	80	80	80	80	Estimated cloud coverage 80%.
11/24/75	1330	0	100	100	100	100	100	Estimated cloud coverage 95%.
11/27/75	1200	0.01	60	60	8	8	8	Estimated cloud coverage 100%.
11/30/75	1230	0	150	150	150	150	150	Estimated cloud coverage 40%.

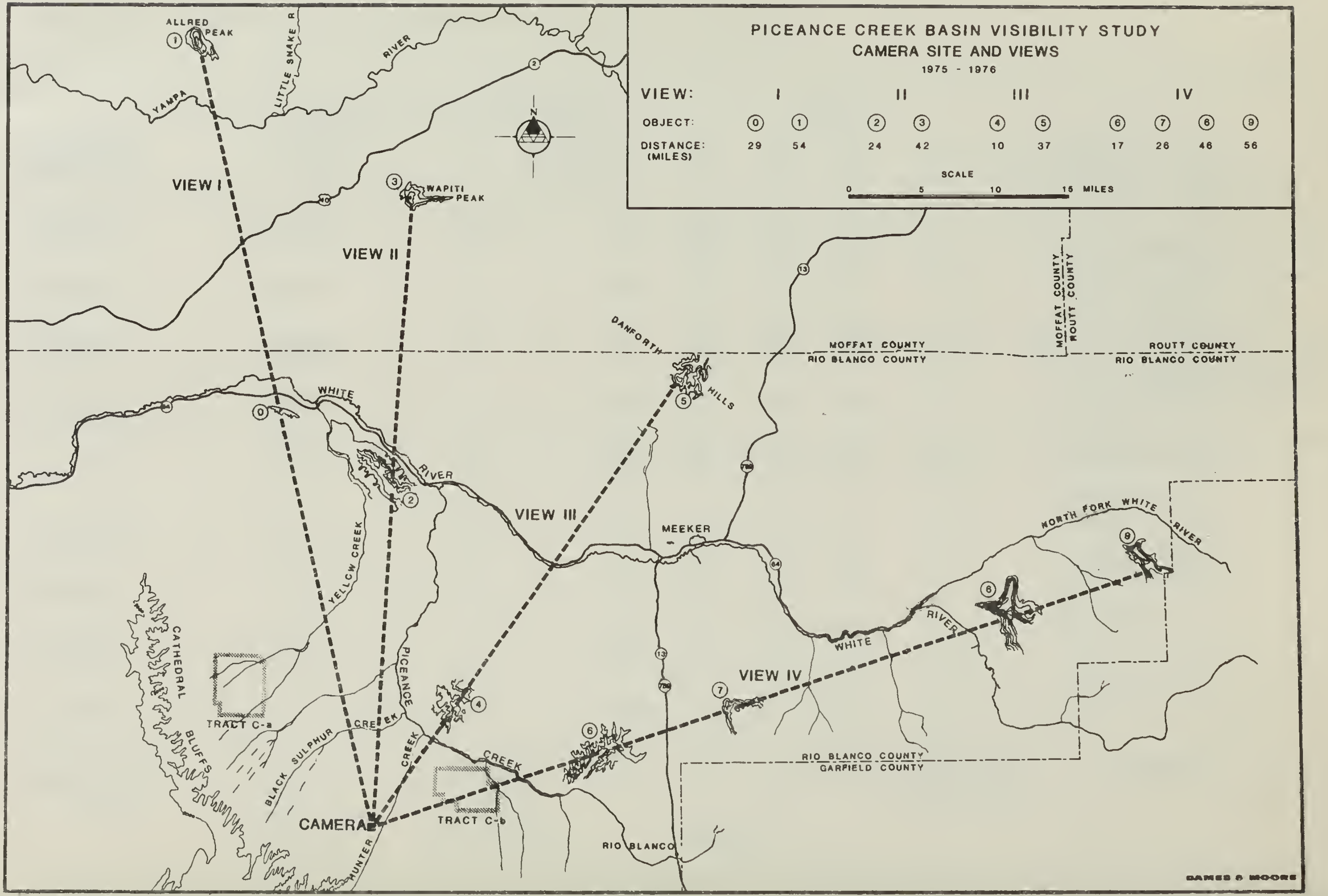

Figure 2.2-20. Basin-wide visibility study sites.

The results of these visual range measurements and their statistical analysis are presented on a daily, monthly, and seasonal basis.

2.2.3.5.3 (b) Results

During the Fall 1975 monitoring period, of the possible 308 range measurements made on 11 scheduled days, there was an 88% recovery of data. No days occurred, however, in which less than half of the measurements were obtained. The principal factor in the loss of visual range measurements was an occasional storm which obscured the view with fog or blowing snow.

Visual ranges obtained during this period were generally high; 95% of the time, visual range exceeded 45 miles and 50% of the time visual range was more than 93 miles. Daily mean visual ranges fluctuated considerably during the period; variations of 30 to 40 miles were not uncommon. The daily mean visual ranges obtained every 6th day during the Fall quarter are listed in Table 2.2-9. The visual range statistics for all views combined for each month of the Fall monitoring period is shown in Table 2.2-10. In Table 2.2-11, a visual range summary for each view and for all views combined are listed for the Fall quarter. Definite conclusions cannot be made at this time.

2.2.3.6 Tracer Study Measurements

2.2.3.6.1 Objectives

No change has occurred since Progress Report 2 - Summary. See Section 2.2.3.6.1 in Progress Report 2 - Summary for specific objectives of the Tracer Study measurements.

2.2.3.6.2 Methods

No change has occurred since Progress Report 2 - Summary. See Section 2.2.3.6.2 in Progress Report 2 - Summary for specific methods used in the Tracer Study measurements.

2.2.3.6.3 Results

Tracer study measurements are being scheduled.

2.2.3.7 Snow Course Measurements

2.2.3.7.1 Objectives

This special study routine is designed to provide additional information to the basic precipitation measurements. With this information, precipitation in the form of snow at Site 1 can be segregated from the automatic precipitation measurements.

Table 2.2-9 Mean Visual Range (Miles) for Each Day of Monitoring Piceance Creek Basin, Colorado. Fall, 1975

Date	Mean Visual Range	Date	Mean Visual Range
September 25*	103	November 2	106
26*	87	8	66
27	59	14	130
		20	80
October 3	93	26	95
9	116		
15	66		
21	99		
27	63		

*Half-day practice session

Table 2.2-10 Visual Range (Miles) Statistics for All Views Combined for Each Month of Monitoring. Piceance Creek Basin, Colorado. Fall, 1975

Month	Mean	Maximum	Minimum
September	77	131	42
October	89	144	44
November	99	149	24

Table 2.2-11 Visual Range Summary (Miles). Piceance Creek Basin, Colorado. Fall, 1975

View	Mean	Maximum	Minimum
I	93	149	37
II	77	142	42
III	92	146	24
IV	101	148	48
Composite	91	149	24

2.2.3.7.2 Methods

No change has occurred since Progress Report 2. See Section 2.2.1.2 in Progress Report 2 for specific methods used in snow course measurements.

2.2.3.7.3 Results

The initial snowfall since summer 1975 occurred in this quarter, fall 1975. The maximum snowfall was 7.0 in, see Table 2.2-9.

Table 2.2-12 Snow course measurements for Fall 1975, RBOSP

Date of Sample	Total Snow Depth (in.)	Water Equivalent (in. of H_2O)
10/23/75	6.0	0.02
11/9/75	1.5	0.05
11/27/75	2.5	0.03
11/30/75	3.0	0.10

2.3 TERRESTRIAL STUDIES

The terrestrial program is designed to gather two years of baseline data on vegetation, small mammals, large mammals, mammalian predators, avifauna, herpetofauna, invertebrates, domestic livestock, and threatened and endangered species. A variety of standardized methodologies is employed to gather these data in the field. All studies are designed to gather the definitive data necessary to describe existing ecosystems as required by the environmental stipulations in the oil shale lease.

2.3.1 Vegetation

2.3.1.1 Objectives

No changes have been implemented since Progress Report 4-Summary. See Section 2.3.1.1 in Progress Report 4-Summary for objectives of the vegetation studies.

2.3.1.2 Methods

No changes have been implemented since Progress Report 4-Summary. See Section 2.3.1.2 of Progress Report 4-Summary for specific methods used in vegetation studies.

2.3.1.3 Results

Ten different vegetation types and associations of these types were sampled on or near Tract C-a during September, 1974. Thirty-five permanent transects were sampled only for the herbaceous stratum in September while 27 non-permanent transects were sampled for herbaceous, shrub and tree strata. Permanent and non-permanent transect data were combined for all sampling periods during 1975 to provide an accurate description of study area vegetation types and associations of those types.

The flora identified during all sample periods in the Tract C-a study area included 5 tree species, 36 shrub species, 169 forb species and 46 grass and/or grasslike species. Additions to the list of plant species encountered on the study area (See Section 2.3.1.3 of Progress Report 4-Summary) are included in Table 2.3.1.

Table 2.3-1 Additions to the list of plant species observed to date in the vicinity of Tract C-a for RBOSP (See Section 2.3.1.3 of Progress Report 4-Summary)

Abbreviation	Species
	Herbaceous (Non-grasslike)
Asca 4[1]	*Aster campestris* Nutt.;[2] (Compositae),[3] Hemi[4] aster, (N)[5] (N)[6]
Gymu	*Gymnolomia multiflora* (Nutt.) Benth & Hook.; (Compositae), Hemi, showy goldeneye, (N) (V)
Memu 2	*Mentzelia multicaulis* (Osterhout) Goodman; (Loasaceae), Hemi, mentzelia, (N) (V)
Niat	*Nicotiana attenuata* Torr. ex. S. Wats.; (Solanaceae), Ther, Coyote tobacco, (N) (V)
Plpa	*Plantago patagonica* Jacq.; (Plantaginaceae), Ther, Patagonia Indianwheat, (N)
Sesp	*Senecio spartioides* T&G (Compositae), Hemi, Broom groundsel, (N) (V)
Somu	*Solidago multiradiata* Ait. var. *scopulorum* A. Gray; (Compositae) Hemi, low goldenrod, (N) (V)
Thwr	*Thelypodium wrightii* A. Gray; (Curciferae), Hemi or Ther, (N) (V)
WYETH	*Wyethia* sp. Nutt.; (Compositae), mule-ears
	Grasses and Grass-likes
ARIST	*Aristida* sp. L. Three awn, (N)
Brpo	*Bromus porteri*, (Coult.) Nash; (Gramineae), Hemi, nodding brome, (N)
Cado	*Carex douglesii* Boot in Hook.; (Cyperaceae), Cryp, Douglas sedge, (N) (V)
Dist	*Distichlis stricta* (Torr.) Rydb.; (Gramineae), Hemi, inland saltgrass, (N) (V)

Table 2.3-1 (Continued)

Abbreviation	Species
	Grasses and Grass-Likes (Continued)
Mebu	*Melica bulbosa* Geyer; (Gramineae), Cryp, onion grass, (N)
Stvi	*Stipa viridula*, Trin.; (Gramineae), Hemi, green needlegrass, (N)

1/ Abbreviation of genus and species in a four letter code (Plummer et al., 1966).

2/ Author citation, nomenclatural authority cited after each species name and delineated by a semicolon.

3/ The family of plants to which a species belongs in parenthesis.

4/ Lifeforms of Plants (Raunkiaer, 1934).

Phan (Phanerophyte) - Perennating bud at least 0.25 m above soil surface.
Cham (Chamaephtye) - Perennating but between 0 and 0.25 m above soil surface.
Hemi (Hemicryptophyte) - Perennating but in soil surface.
Cryp (Cryptophate) - Perennating buds covered by soil or water.
Ther (Therophyte) - Annual plants, perennating buds contained in seed.
Succ (Succlent) - Stems enlarged; serve as water storage organ.

5/ (V) Voucher specimen collected.

6/ Origin of herbaceous species:

(N) - Native to the North American Continent.
(I) - Introduced from outside the North American Continent.

Aspen - The aspen type on the study area is characterized by the constant presence of aspen (Populus tremuloides) and dense and diverse shrub and herbaceous strata, consisting primarily of serviceberry (Amelanchier utahensis and A. alnifolia) in the shrub stratum and elk sedge (Carex geyeri) in the herbaceous stratum.

The type ranges in elevation from 8,140 ft to 8,560 ft on steep, north- and east-facing slopes. The soils are generally deep sandy loams with large accumulations of organic matter.

The type is bordered at the higher elevations by the Douglas-fir type and at the lower elevations by the mixed brush type. A few seedlings of Douglas-fir were found in areas where the aspen and Douglas-fir type bordered each other. Although aspen often precedes Douglas-fir in succession, the low presence and reproductive success of Douglas-fir in aspen stands indicated that most stands were not being replaced by Douglas-fir in the study area. The large number of quaking aspen saplings and lack of mature trees in size classes greater than 4 cm (9.4 in.) indicated a relatively high mortality rate and rapid turnover of individuals within the aspen population. This observation agrees with tree core samples collected by Vories (1974), which showed 67% of the quaking aspen to be under 6 in. in diameter and less than 48 years old. Only 1% of the quaking aspen trees were above 12 in. in diameter and over 64 years old. Also noted was the high incidence of heart rot in the larger size classes of quaking aspen.

Aspen reproduction by seeds is very rare, and nearly all populations are clonal (sharing a common root system which sends up individual stems). Despite the short life span of individual trunks, the substantial resprouting observed in nearly all stands sampled indicates that most aspen stands within the study area are presently self-sustaining.

The diverse (14 species) shrub stratum is dominated by Saskatoon serviceberry and Utah serviceberry. These species provide 19% and 14% cover, respectively. Common black chokecherry, 12% cover, is also present. Mountain snowberry is common as a low shrub and may dominate in more open stands, especially near the forest edge. Species such as Rocky Mountain maple and Greene's mountain ash were found in the moist sites. Phenology data indicate that the dominant shrub species, serviceberry and chokecherry, bloom in the spring and produce ripening fruits by July. Common understory plants such as snowberry and Wood's rose bloomed in July, indicating a sustained period of flowering within the shrub stratum of this type, which may reflect a long period of available moisture.

Forbs characteristic of the summer growth included Canada violet, mountain thermopsis, sweetroot, and northern bedstraw. Elk sedge achieves its highest cover values in the fall (6%) while most of the forb species become reduced in total cover. Low goldenrod did not account for a large portion of the total cover (2% in July and 1% in September) but is strikingly noticeable in aspen stands of the study area because of its height.

The margins of the aspen stands were relatively open and grazed by livestock. The interiors of the stands were steep and tangled by shrubs and fallen trees with no indication of livestock grazing.

Douglas-fir - The Douglas-fir type is characterized by the constant presence of Douglas-fir, and a dense and diverse shrub stratum. The herbaceous stratum is dominated by elk sedge. The Douglas-fir type is restricted to higher elevations in the study area near the summit of Cathedral Bluffs, occurring on steep north- and east-facing slopes. Douglas-fir dominates the tree stratum, providing nearly 100% relative cover, and occurs at densities of approximately 500 individuals per hectare. Uniform distribution of trees in the mature size class, and a very large percentage of all trees occurring in the smallest size class, indicate that Pseudotsuga menziesii is actively reproducing, but also has a high seedling mortality.

The shrub stratum in the Douglas-fir type consists of two layers. The upper layer is dominated by Utah serviceberry, which occurs in large clones, and ranges in height to 3 m (9.7 ft). The lower layer is dominated by mountain snowberry, which occurs at high densities and is usually less than 1 m (3.3 ft) in height. Together, the two species provide 40 to 70% of the total cover, and up to 80% of the total density. Both species were leafing out in May-June and snowberry was flowering and serviceberry was forming fruits in July. Both species were recorded as vegetative in September.

Herbaceous species diversity and total cover is lower than in aspen stands at comparable elevations, indicating that Douglas-fir may exert a greater limiting influence on the herbaceous stratum than aspen. Elk sedge was the dominant species during all sampling periods, providing relatively constant cover of approximately 10% throughout the year. Maximum cover and species diversity occurred during July, when 23 species provided 23% total cover. Approximately 80% of the same species were present during sequential sampling periods. The dominant species, elk sedge, flowers in late spring shortly after snowmelt.

Mixed Brush - The mixed brush type is characterized by the tall shrub life form of 3 species: Gambel oak, Utah serviceberry, and true mountain mahogany. The type occurs over an elevational range of 7,150 ft to 8,600 ft. The type occurs on a wide range of slopes from steep to gentle, and at all slope aspects. The best shrub development occurs on the steep north- and east-facing slopes within the type. The soils associated with this type are shallow to moderately deep, well-drained sandy loams.

The mixed brush type intergrades with the aspen and Douglas-fir types on steep slopes at the upper elevations and on the more gentle upland slopes and ridges it intergrades with the sagebrush type. At the lower elevations, the mixed brush type gradually intergrades with the sagebrush type or may exist as islands on steep north-facing slopes within the pinyon-juniper type.

The shrub stratum shows a wide range of diversity with up to 20 species and is divided into a tall shrub layer dominated by Utah serviceberry (52% relative cover) and a low shrub layer dominated by big sagebrush or mountain snowberry. Gambel oak increases in importance in the wetter stands and true mountain mahogany increases in importance on drier slopes or shale outcroppings.

Phenology data indicate that the dominant shrub species, Utah serviceberry and Gambel oak, flower during the spring; snowberry flowers during mid-summer; and composite species, such as big sagebrush and rabbitbrush (Chrysothamnus sp.), flower in the fall. In the spring, elk sedge was the only dominant species providing over 2% cover out of the total cover of 5%. Total cover increased to 11% in July, and declined to 8% in September. In September, elk sedge was the only species contributing over 1% cover.

The mixed brush type is represented by two plant associations in the study area. The Utah serviceberry-Gambel oak association is distinguished by the presence of Gambel oak and a dense shrub stratum. Ordination of transects sampled in this association by elevation and slope indicates the narrow elevational range of this association and its restriction to cool, steep slopes. Ferchau (1973) and Vories (1974) observed that Gambel oak is susceptible to late frosts and is infrequent in its production of viable acorns in the study area. Gambel oak grows best in areas with considerable available water, intermediate temperatures, and moderate light (Christensen, 1949). It cannot tolerate intense grazing, strong winds, very warm or cold mean annual temperatures, or deep shade. It has a wide range of tolerance to soil types.

The clonal nature of both Utah serviceberry and Gambel oak, as well as their dense cover (39% and 13% cover, respectively), produces an almost impenetrable thicket. Mountain snowberry is found in abundance in the openings between the taller shrubs and beneath serviceberry plants. Common black chokecherry and Saskatoon serviceberry are found in the wettest stands within the association. Big sagebrush (8% cover) is found commonly in more open stands and near the edges of the stands.

The herbaceous stratum is relatively well-developed (maximum of 26% cover) and is dominated by elk sedge.

The second mixed shrub association is the Utah serviceberry-mountain snowberry association. This association is distinguished by dispersed large Utah serviceberry plants (26% cover) interspersed by mountain snowberry (12% cover). It is found on dry, low elevation slopes within the mixed brush type. Elevations average approximately 92 m (300 ft) less than elevations for the previous mixed brush association. The elevational ranges of the two associations nearly overlap in the study area. This association occurred on gentle slopes and at all slope aspects although it was predominantly encountered on north- and east-facing slopes.

Big sagebrush (8% cover) is common in the openings among the large Utah serviceberry plants. True mountain mahogany is found in the driest stands, usually on shale outcroppings. Other species indicative of dry sites include horsebrush, pinyon pine, Utah juniper, and prickly pear. The presence of pinyon pine and Utah juniper in the shrub stratum, in addition to the scarred stumps of these two tree species in some of the stands of this association, indicate successional relationships and competition between shrub species and pinyon and juniper.

The herbaceous layer is characterized largely by drought-resistant grasses and forbs. The plants tend to be well spaced with no clear dominant or constant species. Five species showed greater than 1% cover: needle-and-thread sulfur eriogonum, Sandberg bluegrass, Nuttal's goldenweed, and Indian ricegrass.

Pinyon-Juniper - The most extensive vegetation type in the Piceance Basin and the study area is dominated by pinyon pine and Utah juniper. In the Piceance Basin the pinyon-juniper type is completely overlapped in elevation range (6,100 ft to 7,875 ft) by the sagebrush type (5,975 ft to 8,800 ft) (Vories, 1974). In the study area, the pinyon-juniper type was sampled over an elevational range of 6,500 to 7,660 ft.

Pinyon-juniper and sagebrush are segregated by the differing abilities of the dominant species to compete with each other under differing soil conditions. Sagebrush occupies the valleys, mesas, or gentle slopes where fine-textured, deep soils are prevalent. Pinyon-juniper occupies the ridges, canyons, or steep slopes where coarse rocky soils predominate. On soils intermediate in texture and depth there is a great deal of competition between sagebrush, pinyon pine, and juniper. The pinyon-juniper type also interacts with the mixed brush type, which occupies slopes where snow accumulates in winter within the elevation range of the pinyon-juniper type (Woodbury, 1947).

Within boundaries extending 1 mi from the Tract C-a border, 75% of the pinyon-juniper transects sampled during 1975 occupy shallow, well-drained soils formed from sandstone on steep to gentle upland slopes and ridges. Thirteen percent of the transects occurred on steep rock outcrop areas on south-facing slopes along major drainages. Eight percent of the transects occurred on soils originating from calcareous sandstone and 4% occurred on moderately deep, well-drained soils formed from sandstone and windblown materials. The pinyon-juniper type was found on all slope aspects and showed no significant preference for any particular aspect.

The tree canopy of pinyon pine and Utah juniper in the study area is usually very open (21-23% total cover), with the individual trees well spaced (250-300 individuals/ha). The density of individual stands has been observed by Woodbury (1947) to increase with the increased available moisture at higher elevations. Woodbury also noted the tendency for juniper to be prevalent on drier sites at lower elevations and pinyon pine to be more prevalent on wetter sites at higher elevations. The larger basal area for Utah juniper (23 m^2/ha) versus that for pinyon pine (14 m^2/ha),indicates the generally larger trunk size and probable greater age of Utah juniper on the study area. It was shown by Vories (1974) that Utah juniper has a higher average than pinyon pine within any given size class for the Piceance Basin.

Ordination of shrub and tree cover for the pinyon-juniper type against elevation indicates that the species and stratum components show a pattern often expressed in other studies. In a study of the synecology of the pinyon-juniper type in the Great Basin and Colorado Plateau, West et al. (1975) found that tree cover of these two species increased to a maximum at about 2,200 m (approximately 7,260 ft) elevation and then declined above this point. Maximum tree cover in the study area fell very near this value. Shrub stratum cover showed an inverse pattern, providing greatest cover at the lower and higher extremes of the range of the two dominant tree species. This study also indicates that Artemisia tridentata increases in cover at the elevational extremes of the pinyon-juniper type, as indicated by the range of the pinyon-juniper sagebrush association in this study.

The shrub stratum is diverse (15-18 species) but maintains a low average cover (8-11%). The shrub cover has been noted to increase with increasing available moisture and the removal of the tree canopy by fire or chaining. As indicated above, the shrub cover decreases with the increasing maturity of the tree species and reduction of available moisture by erosion. The most constant shrub within the type is big sagebrush. Seedlings and saplings of pinyon pine are common in the shrub stratum. Utah serviceberry is moderately frequent (40-60%) in the type and maintains a comparatively high cover (1-3%).

The herbaceous stratum is characterized by a high diversity (66 species), low total cover (3-6%) and the predominance of 3 grass species: slender wheatgrass, Sandberg bluegrass and Indian ricegrass. Seasonal changes in cover are minimal and range from 2% in May-June to 6% in July, 4% in September. No one species contributed more than 0.5% cover in May-June. Three species, slender wheatgrass, Sandberg bluegrass, and Indian ricegrass, contributed over 0.5% cover each in July, while only slender wheatgrass and Sandberg bluegrass contributed over 0.5% cover each in September. The lack of herbaceous cover can be the result of several factors. The ability of pinyon and juniper litter to inhibit germination (Jameson, 1961, 1966) is a partial explanation for the decrease in understory cover and diversity with the increasing age of a stand. The shade from the tree canopy is not usually effective in the availability of reflected light (Shirley, 1945). Shade from the tree canopy may be beneficial to some species by reducing evaporation rates (Jameson, 1966). This was noted in the study area for Fremont goosefoot and several moss species. Competition for available moisture is thought to be more important in the distribution of understory species (Johnson, 1962; Arnold, 1964) than any other single factor in the pinyon-juniper type.

Three recognizable associations were distinguished for the study area pinyon-juniper type. They are the pinyon pine-Utah juniper-mixed brush association; the pinyon pine-Utah juniper-big sagebrush association; and the pinyon pine-Utah juniper-woodland association.

The pinyon-pine-Utah juniper-mixed brush association has the highest average elevation of the three associations (7,140 ft). It is found primarily on cooler north- and east-facing relatively steep(averaging 11°) slopes. The total tree cover for this association is lower than the average for the pinyon-juniper type as a whole (15 versus 21-23%). The high ratios of pinyon cover (11%), density (115 individuals/ha) and basal area (17 m^2/ha) to juniper cover (4%), density (58 individuals/ha) and basal area (6 m^2/ha) may be indicative of the relatively high moisture availability within this association.

The shrub stratum within this association has the greatest cover (20%) and density (5,867 individuals/ha) of any of the three associations. The most abundant shrub species are those typical of the mixed brush type, Utah serviceberry (8% cover), big sagebrush (7% cover), bitterbrush (1% cover) and true mountain mahogany (1% cover). Young pinyon pine plants are also frequent (90% frequency) in the shrub stratum.

The herbaceous stratum is not well developed and only supports 21 species within the total cover of 4%. Slender wheatgrass was the only species with more than 1% cover.

The pinyon pine-Utah juniper-woodland association represents the most mature stage of the pinyon-juniper type. This association's average elevation (6,900 ft) lies near the average elevation for the pinyon-juniper (6,940 ft). This association shows no preference for any particular slope aspect and is usually located on gentle (7°) upland slopes and ridges. The slightly higher cover (14%) and basal area (39 m^2/ha) of pinyon pine as compared to the cover (13%) and basal area (21 m^2/ha) of Utah juniper appears to agree with Woodbury's (1947) suggestion that pinyon tends to replace juniper in mature stands. The high total cover (27%) and basal area (60 m^2/ha) of tree stratum for this association is indicative of the relatively large size of the trees. The low total cover of the shrub (3%) and herbaceous (4%) strata is indicative of the monopolization of the habitat by the tree species despite the moderate tree canopy cover. No shrub species provided greater than 1% cover and only one herbaceous species, Sandberg bluebrass, exhibited more than 1% cover.

The pinyon pine-Utah juniper-big sagebrush association occurred at the lowest average elevation (6,310 ft) within the type. It is generally found on gentle upland slopes and ridges and shows no preference for a particular slope aspect. The comparatively high cover (11%), density (181 individuals/ha), and basal area (21 m^2/ha) of Utah juniper over the cover (9%), density (119 individuals/ha), and basal area (4 m^2/ha) of pinyon pine may be indicative of the relatively dry conditions that prevail at these sites.

The shrub stratum is dominated by big sagebrush with 7% cover. The remaining 13 shrub species contributed only 2% of the total 9% shrub cover and none of these species contributed more than 1% cover. The herbaceous stratum is the best developed of the three associations with 8% total cover. The 6 species with the greatest cover are all grasses typical of fairly dry sites: slender wheatgrass, prairie junegrass, needle-and-thread, western wheatgrass, and Indian ricegrass.

Sagebrush - The sagebrush type on the study area is characterized by the constant presence, high cover, and high density of big sagebrush in the shrub stratum and by a herbaceous stratum with high species diversity, but generally low cover. The sagebrush type occurs over a wider elevational (6,420-8,580 ft) range than any other type found on the study area and generally occurs on gentle slopes. The sagebrush type occurred on deep alluvial soils in valley bottoms (Glendive series) and on mixtures of moderately deep aeolian and residual soils (Rentsac and Piceance series), and on gently sloping uplands (Yamac series) and shallow residual soils of the Rentsac series, located primarily on uplands and valley side-slopes.

On the study area, the sagebrush type intergrades with the pinyon-juniper type at lower elevations along drainages and on uplands along the ridges above the major drainages. Boundaries between sagebrush and pinyon-juniper types are frequently very distinct along transitions between alluvial bottomland sagebrush stands and pinyon-juniper stands occurring on steep shale outcrops. Transitions are often very gradual between the two types in areas where soil depth does not vary sharply. Big sagebrush is a frequent component of the understory in the pinyon-juniper type, and decreases in abundance with increasing density and cover of pinyon and Utah juniper. The sagebrush type also intergrades gradually with the mixed brush type on gentle upland slopes. Cover of Utah serviceberry increases with increasing elevation and with transitions to cooler slope aspects.

The shrub stratum in this type contributes an average cover of 30% and average densities of greater than 13,000 individuals/ha over the study area. Although shrub species were encountered in this type, big sagebrush generally provided 75% of total cover, and 60 to 80% of the total density in the transects sampled. Frequent associates in the sagebrush type are rabbitbrush and Utah serviceberry. Phenology of common shrub species is divided between fall blooming composite species (big sagebrush, rabbitbrush) and spring and early summer flowering species (Utah serviceberry mountain snowberry).

The herbaceous stratum in this type contributes cover ranging from less than 10% during May-June, to a maximum of 17% during July. The herbaceous stratum is characterized by a large number of species (nearly 100) which are heterogeneously distributed, without strong dominance by any one species This heterogeneity reflects the wide elevational range of the type, which includes a number of microclimates within its boundaries. The dominant species over the type for all sampling periods, Poa sp., ranged in cover from 1% in May-June to nearly 2% in July. There is a high persistence of species, with approximately 70% of all species shared in common between sequential sampling periods. Flowering of herbaceous species occurs primarily in early to late spring, when highest soil moisture levels are present. Almost no species were reproductively active during September, indicating high moisture stress near the soil surface in late summer. By contrast, big sagebrush and rabbitbrush were flowering during this period.

The sagebrush type is divided into four major associations, the upland and bottomland sagebrush, rabbitbrush, and greasewood associations. The rabbitbrush and greasewood associations are discussed in separate sections. The sagebrush associations (upland and bottomland sagebrush) are distinguished from each other by their occurrence on different soil types (alluvial versus residual), and by the taller stature and greater density and cover of bottomland sagebrush stands. Ordination of these two associations against elevation indicates that bottomland sagebrush has a restricted elevational range due to its occurrence at the bottom of drainages. Upland sagebrush has a much wider elevational range, occurring from nearly level areas on lower elevations of 84 Mesa up to high elevation east slopes just below the summit of Cathedral Bluffs. Cover of the bottomland sagebrush association does not show a strong response to increase in elevation. Cover in upland sagebrush transects increased slightly with elevation, but total cover was almost always less than cover in bottomland associations, regardless of elevation. These cover differences probably reflect a more reliable moisture supply in bottomland sagebrush stands. Herbaceous cover increased with elevation in the upland sagebrush association, but remained at a low level on all bottomland associations, reflecting either substantial competition from the shrubs or intensive grazing.

The shrub stratum of the bottomland sagebrush association contributed a total cover of 43%, and a total density of 18,880 individuals/ha. Common species were big sagebrush, rubber rabbitbrush and mountain snowberry. Five percent cover was recorded for the herbaceous stratum during July. Western wheatgrass and great basin wild-rye were the dominant herbaceous species.

The shrub stratum of the upland sagebrush association contributed a total cover of 30%, and a total density of 9,345 individuals/ha. Other frequent species were rabbitbrush, Utah serviceberry, and mountain snowberry. Fifty-one herbaceous species contributed 26% total cover during July. Tailcup lupine and Sandberg bluegrass were the dominant species on the transects sampled.

The greasewood association occurs as small isolated patches within the bottomland sagebrush association. It is frequently an indicator of saline-sodic soils (Rickard, 1967), and occurs on deep, well-drained soils formed in alluvial deposits which usually have dependable groundwater. It shares dominance with big sagebrush which is an atypical situation for the two species. It is unclear whether on the study area this is due to disturbance or relative soil alkalinity.

Phenological data indicate that greasewood flowers during mid-summer, forming seeds during late summer and early fall. The high density of sagebrush seedlings in greasewood stands indicate that greasewood may be a secondary successional element in bottomland sagebrush stands on the study area.

Seasonal variation in the herbaceous stratum shows that three annuals, annual stickseed, Fremont goosefoot and pinnate tansey mustard were the most common species contributing over 50% of a total 12% cover during May-June. Western wheatgrass was the most common perennial species. Stands sampled in Yellow Creek have been seeded to crested wheatgrass.

By July the total herbaceous cover had increased from 12% cover in May-June to 29% cover. The greatest cover was again attained by annual species, summer cypress and lambsquarter goosefoot. These species showed a tendency to be clustered together by their high sociability values. Western wheatgrass was the most common perennial species.

Phenological data indicate that most herbaceous species flower in spring when soil moisture is high after snowmelt.

The rabbitbrush association sampled in the study area represents a successional stage in the bottomland sagebrush association. Most of the stands sampled in the study area are on abandoned agricultural lands or show evidence of the removal of big sagebrush by burning, defoliation or mechanical means. Burning of rabbitbrush normally kills it back to the soil surface only and then it sprouts from the roots and increases in density by seedling establishment (Daubenmire, 1975). Rabbitbrush has been shown to dominate and periodically reestablish itself for at least 15 years. Reduced populations of rabbitbrush persist in communities where dominant big sagebrush plants are 40 to 50 years old (Young and Evans, 1974).

In the study area the elevational, topographic, and edaphic factors are essentially the same for the rabbitbrush association as they are for the bottomland sagebrush association. It is found on floodplains and low terraces along the major drainages surrounded by the sagebrush type. Rabbitbrush is always the dominant species with 90 to 91% relative cover. In the study area, rabbitbrush forms flower buds during mid-summer and flowers in late summer and early fall.

The herbaceous stratum may be dominated by great basin wildrye (80% relative cover) which can completely conceal the shrubs by mid-summer by attaining a greater height. Young stands of rabbitbrush were more likely to have an herbaceous understory of annuals such as Fremont goosefoot.

Herbaceous species were found flowering during May-June and disseminating seeds by July. Some reproductive activity was still evident in September, unlike the majority of bottomland sagebrush and greasewood transects sampled, where nearly all species were vegetative, dead, or dormant.

Shadscale - The shadscale type occurs over a short elevational range (6,960 - 6,800 ft) in narrow bands on steep, generally south-facing slopes adjacent to major drainages within the study area. It occurs on rock outcrops or very shallow soils derived from sandstone cliffs or platy siltstone outcrops.

Total shrub cover is low (14 to 16%). Shadscale shares dominance with three shrubs from the sagebrush type: big sagebrush, rabbitbrush and rubber rabbitbrush indicating its close relationship to the sagebrush type.

Herbaceous cover was extremely low in May-June, totaling less than 1%. In July, it had increased in total cover to just under 3% with eriogonum measuring just over 1% cover. In September, the cover values changed very little, decreasing in total cover by less than 0.5%. Indian ricegrass showed a high constancy in all sampling periods.

Bald - The bald type is characterized by the absence of developed tree and shrub strata, and a diverse herbaceous cover consisting of perennial forbs and grasses. The term "bald" is derived from the "heath bald" communities found on the summits of some peaks in the Appalachian Mountains (Whittaker, 1956). Although not analagous to the Appalachian Balds, the term "bald" adequately describes the open bare slopes surrounded by communities dominated by taller shrubs or trees, and also implies a harshness which characterizes those windswept areas that occur along the summit of Cathedral Bluffs, and on exposed ridges at lower elevations. The bald type ranges in elevation from 7,230 to 8,550 ft and occurs almost exclusively (80%) on west slope aspects facing the prevailing wind. Transects were sampled primarily on the Rentsac soil series. Field observations indicate that soils were frequently extremely shallow and rocky.

Shrub species occur sparingly on the bald type (1-5% cover) and are usually of very low stature. Utah serviceberry provided the most cover, but was generally restricted to more protected sites. Low stature shrubs characteristic of this type were rabbitbrush and horsebrush.

The diverse (60 species) herbaceous stratum consists of low grass and forb species that frequently form a carpet-like mat that assists in reducing desiccation by strong winds.

Total cover ranges from less than 10% in May-June to greater than 20% in July. Dominance is usually shared by several species. Species contributing greatest cover were slender wheatgrass, prairie junegrass, tufted milkvetch, and mat penstemon. Many of the species encountered in the bald type were also encountered in the herbaceous stratum of the sagebrush and pinyon-juniper types, indicating a compositional continuity with these communities.

During the May-June sampling period, nearly all species were in a vegetative state, over half the species were flowering or forming seeds in July, and nearly all species declined to a vegetative state in September.

Riparian - The riparian type in the study area consists of three different types of environments: small springs in open alluvial bottomlands that have been converted to pastureland occupied by common pasture weeds; hillside springs and seeps along the bottom of steep draws (e.g., Cottonwood Spring) which are not heavily grazed and contain a number of unusual species for the Piceance Basin; and drainageways of intermittent streams that contain species characteristic of the bottomland sagebrush association.

Tree species were not frequent in this type. Aspen appeared on one transect sampled at a high elevation. A few large individuals of narrowleaf cottonwood were observed at Cottonwood Spring.

Dominants in the shrub stratum, big sagebrush and rubber rabbitbrush are found along the drainageways of intermittent streams. In a few isolated areas (Cottonwood Spring, Duck Creek), more characteristic riparian species were found: water birch, willow, and red osier dogwood. In wet pastures, shrubs are largely absent except rubber rabbitbrush which occurs around the fringes. Total shrub cover for the type ranges from a low 2% cover on disturbed pasture sites to 25% cover when several transects were sampled in hillside springs and along intermittent streams.

Permanent herbaceous quadrats are located in wet pasture sites. As a result, the high total cover (50 to 80%) reflects the very moist growing conditions. Quackgrass, Kentucky bluegrass, and common dandelion were common constituents of wet pastures. Several unusual herbaceous species were collected on moist sites in the vicinity of Cottonwood Spring. These included an endemic columbine, and alpine pyrola, a species restricted to cool, damp sites. Fowl mannagrass was found only in areas of permanent running water.

Phenology of several species occurring in pastureland areas could not be evaluated because the areas were heavily grazed. Species in streamside habitats were frequently found to be flowering and forming seeds on the same plant, possibly indicating a longer flowering season in these areas with greater available moisture.

2.3.2 Grazing Exclosure

2.3.2.1 Objectives

No changes have been implemented since Progress Report 4-Summary. See Section 2.3.2.1 in Progress Report 4-Summary for objectives of the grazing exclosure study.

2.3.2.2 Methods

No changes have been implemented since Progress Report 4-Summary. See Section 2.3.2.2 in Progress Report 4-Summary for specific methods used in the grazing exclosure study.

2.3.2.3 Results

In the grass forb stratum, rodent-proof compartments yielded a mean of 0.90 g/sample or 101.93 kg/ha of oven-dried herbage. The deer and cattle proof compartment yielded 4.35 g/sample or 491.10 kg/ha, and the compartment excluding only cattle yielded 3.21 g/sample or 363.04 kg/ha. The "control" or unfenced area yielded 2.54 g/sample or 286.71 kg/ha.

In the shrub stratum, the .01 acre plot within the rodent-proof compartment contained 1.00 m^2 Artemisia tridentata for an absolute area of 249.39 m^2/ha. The deer proof compartment shrub plot contained a total area of 2.72 m^2 Artemesia tridentata for an absolute area of 680.35 m^2/ha; 0.44 m^2 Chrysothamnus nauseosus for an absolute area of 109.07 m^2/ha; 0.01 m^2/ C. viscidiflorus, for an absolute area of 1.95 m^2/ha; and 0.10 m^2 Juniperus osteosperma for an absolute area of 24.05 m^2/ha. The cattle-proof compartment shrub plot contained 0.14 m^2 Amelanchier utahensis, for an absolute area of 35.82 m^2/ha; 4.03 m^2 Artemisia tridentata, for an absolute area of 1006.66 m^2/ha; 1.04 m^2 Chrysothamnus nauseosus, for and absolute area of 260.72 m^2/ha; 0.32 m^2 Juniperus osteosperma for an absolute area of 80.52 m^2/ha; 0.05 m^2 Pinus edulis, for an absolute area of 12.27 m^2/ha; and 1.52 m^2 Purshia tridentata for an absolute area of 379.57 m^2/ha. The "control" plot contained 0.10 m^2 Amelanchier utahensis, for an absolute area of 24.05 m^2/ha; 3.82 m^2 Artemisia tridentata, for an absolute area of 954.20 m^2/ha; 2.67 m^2 Juniperus osteosperma, for an absolute area of 667.85 m^2/ha; 1.08 m^2 Pinus edulis, for an absolute area of 269.57 m^2/ha; and 3.10 m^2 Purshia tridentata, for an absolute area of 773.87 m^2.

In the canopy stratum, the periphery of the sampling grid in the rodent-proof compartment intercepted 168.5 cm of juniper (Juniperus osteosperma) and 302.4 cm of pinyon (Pinus edulis) above "high line level" (1.83 m). Juniper and pinyon intercepting the line below "high line level" totalled 77.2 cm and 29.1 cm, respectively. In the deer-proof compartment, the upper canopy of the grid perimeter was intercepted by 89.8 cm pinyon. The lower canopy consisted of 152.8 cm pinyon and 78.4 cm juniper. The perimeter of the cattle-proof compartment grid intercepted 156.7 cm of pinyon and 170.1 cm juniper in the upper canopy, 224.4 cm pinyon and 135.8 cm juniper in the lower canopy. Along the perimeter of the grid in the control area, 156.3 cm pinyon and 22.1 cm juniper were intercepted in the upper canopy, and 102.8 cm pinyon and 59.1 cm juniper in the lower canopy.

Shrub photoplot photos are on file as baseline data for comparison with results from future sampling periods.

The above data are baseline material intended for comparison with data from future years. It is important to recognize that initial differences between sample grids may exercise considerable influences on the responses elicited from the various treatments. Current differences can be attributed to slight variations in slope and aspect within and between the sample plots. It should be understood that these influences will exert differential pressures on the responses of each sample site and that these responses will not necessarily be directly proportionate to the degree of protection from grazing and browsing. The responses of sample sites to degrees of release from grazing pressures will be measured in future years with the aforementioned considerations in mind.

2.3.3 Small Mammals

2.3.3.1 Objectives

No changes have been implemented since Progress Report 2-Summary. See Section 2.3.3.1 in Progress Report 2-Summary for the objectives of the small mammal program.

2.3.3.2 Methods

No changes have been implemented since Progress Report 3-Summary. See Section 2.3.3.2 in Progress Report 3-Summary for specific methods used in small mammal studies.

2.3.3.3 Results

The presence of 28 species of small (and medium-sized) mammals has been documented by live, removal, and pitfall trapping, night spotlight censusing, mist netting (for bats) and opportunistic observations in the vicinity of Tract C-a during all sampling conducted between October, 1974 and October, 1975. Data collected during live-trapping operations from over 2,700 individuals, comprising 13 small mammal species, have permitted the formulation of several generalizations concerning the distribution and abundance of small mammal populations among major habitats within the area of investigation. Although these generalizations were drawn from live-trapping data, the generalizations are not necessarily restricted to live-trappable small mammals but are probably applicable to all small (and medium-sized) mammals encountered except, of course, bats.

Data collected during the September-October, 1975 sampling period have been combined with data from all other sampling periods to provide the following generalizations regarding Tract C-a vicinity small mammal ecology over the past year.

Small mammals ultimately depend upon vegetation for food, shelter, and in some cases as their only supply of water. Consequently, vegetation, specifically the amount and kind of vegetation, is the most important factor controlling the distribution and abundance of small mammal populations in the vicinity of Tract C-a. Elevation appears to be important also, especially for some species.

Within habitats sampled below 8,000 ft elevation, the amount of shrub cover appears to be the most important factor regulating the abundance of small mammals. The largest number of small mammals captured per unit trapping effort (e.g., individuals/100 traps) occurred on grid 3 (rabbitbrush), followed in order by grid A (greasewood-sagebrush) and grid 5 (mixed brush). Vegetation data collected from permanent phytosociological transects on or near small mammal grids showed that these grids also exhibited the highest shrub cover of all grids below 8,000 ft. Accordingly, the grid with the fewest captures below 8,000 ft, grid 1 (bottomland meadow), also exhibited the lowest shrub cover.

Although the same trend holds true for grids above 8,000 ft, i.e., more small mammals are encountered in habitats with a higher shrub cover, total small mammal abundance is lower for these grids than for those at lower elevations. This is undoubtedly due to the harsher conditions and shorter growing season at the higher elevation.

Species diversity, as indicated by the Shannon-Weiner index which accounts for both number of species and number of individuals of each species, seems to be tied closely to the presence or absence of trees (i.e., pinyon-juniper) in habitats below 8,000 ft. Of the larger (7.29 ha) grids, the two that consistently showed the highest diversity were the two established within pinyon-juniper woodlands, grid B (pinyon-juniper/south slope) and grid C (pinyon-juniper/north slope). Likewise, grid 4 (pinyon-juniper/mixed brush) had the highest species diversity for the 0.81 ha grids. Pinyon and juniper trees provide food for many small mammal species that eat the highly nutritious pinyon nuts and juniper berries. The latter are more consistently available than pinyon nuts as they remain on trees a large part of the year and are not so completely destroyed by insects as pinyon nuts (Frischknecht, 1975). The cambium of pinyon may also be eaten by certain species and the shreddy bark of juniper is often used in nest building (Frischknecht, 1975).

The value of pinyon and juniper trees as a source of food and potential nesting sites is further emphasized when it is noted that 8 of the 13 species encountered during all live-trapping operations inhabited pinyon-juniper woodlands. In fact, three of the species, piñon mouse, Colorado chipmunk, and bushy-tailed woodrat, were generally limited to this vegetation type. Another species, the golden-mantled ground squirrel, was caught almost exclusively on grids established within or adjacent to pinyon-juniper woodlands.

At elevations above 8,000 ft the harshness of the environment and not the presence or absence of trees is probably a more important determining factor in the distribution of small mammal species. Of the 13 species encountered, only 5 were captured in grids established at the higher elevations.

The two most abundant small mammal species within the vicinity of Tract C-a are the least chipmunk and the deer mouse. Both were represented in samples from every grid and together accounted for 82.45% of the total small mammal abundance. The habitat affinities of the least chipmunk and the deer mouse, as indicated by chi-square values, were almost identical as both species were caught more frequently in habitat types with a high shrub cover.

The golden-mantled ground squirrel, though not nearly as abundant as either the least chipmunk or the deer mouse, was the third most frequently captured small mammal accounting for 5.41% of the total abundance. This species indicated a definite affinity for pinyon-juniper woodlands as did three other species, the Colorado chipmunk, piñon mouse, and the bushy-tailed woodrat, discussed previously.

The other seven trappable small mammal species were captured rather infrequently accounting for only 6.87% of the total abundance. However, some species were predominant in certain habitat types and a definite pattern of macrohabitat preferences was discernible for all.

Captures of the thirteen-lined ground squirrel were limited to the grid established in sagebrush vegetation on 84 Mesa and accordingly the species showed a definite affinity for this habitat. The apache pocket mouse was captured within five different types but showed an affinity for pinyon-juniper woodlands. Merriam's shrew, was only captured once in sagebrush, however, its affinity for that habitat is substantiated by the literature (Armstrong, 1972).

Of the four vole species, the red-backed vole was the most abundant. It is adapted for living at elevations above 8,000 ft (Lechleitner, 1969) and was the predominant small mammal in both Douglas-fir and aspen vegetation. The montane vole showed a definite affinity for bottomland meadow while its cogener, the long-tailed vole indicated an affinity for the thick greasewood-sagebursh-rabbitbrush stands characteristic of the bottomland drainages. The sagebrush vole, as its name implies, revealed a preference for sagebursh as well as for mixed brush.

Of the three species collected by removal trapping for analyses of stomach contents, two, the least chipmunk and the deer mouse, indicated preferences for seeds. However, both utilized succulent materials more frequently in the spring when new seeds were not yet abundant. The deer mouse was slightly more omnivorous in its food habits as invertebrates and vertebrate materials were occasionally observed in stomach contents. Long-tailed voles, collected within the aspen vegetation type, utilized primarily succulent materials. A high percentage of seeds was found in stomachs of specimens collected in early spring, however, when succulent material was not available.

As indicated by both the proportion of juveniles in samples taken from each trapping period and reproductive data collected from least chipmunk, deer mouse, and long-tailed vole specimens, the peak of the reproductive activity for most of the small mammal species encountered appears to occur from May to July. Correspondingly, small mammal population levels are at their highest in late summer after the breeding season. Overwinter mortality results in population lows during early spring.

Several species of small and medium sized mammals not amenable to inventory by the live-trapping techniques employed were documented by other methods. Pitfall traps, established in all major habitats, revealed the presence of both the Northern pocket gopher and masked shrew.

A cottontail and two species of jackrabbits, the white-tailed jackrabbit and the black-tailed jackrabbit, as well as the porcupine, were seen during night spotlight censuses. The censuses confirmed information obtained from the Colorado Division of Wildlife that lagomorph population levels in the Piceance Basin are low.

The presence of two species of bats, the long-eared myotis and the small-footed myotis were revealed by mist netting during June, 1975. Two more species, the California myotis and the hoary bat, were documented during August sampling.

2.3.4 Large Mammals

2.3.4.1 Objectives

No changes have been implemented since Progress Report 2-Summary. See Section 2.3.4.1 in Progress Report 2-Summary for objectives of the large mammal section.

2.3.4.2 Methods

No changes have been implemented since Progress Report 3-Summary. See Section 2.3.4.2 of Progress Report 3-Summary for methods used in large mammal studies.

2.3.4.3 Results

During the reporting quarter aerial surveys and track counts were conducted to determine mule deer migration patterns. Mule deer pellet plot transects were surveyed and pellet groups enumerated to determine the degree of summer mule deer use in the study area. Aerial surveys were conducted twice during November to determine mule deer distribution and numbers in the study area.

Mule deer appeared to be scattered in small groups in areas east and west of Tract C-a during the aerial surveys conducted in November 1975. Relatively more animals were observed west of Tract C-a than east of the tract during aerial surveys for migration movement studies. Mule deer appeared to be moving north eastward during the fall migration period. Summer use of Tract C-a was relatively light, according to pellet plot analyses. Mule deer used the mixed brush areas west of Tract C-a more than any other vegetation type.

Feral horses were located southwest of Tract C-a and on 84 Mesa during this quarter. Elk were not observed during investigations conducted this quarter.

2.3.5 Mammalian Predators

2.3.5.1 Objectives

No changes have been implemented since Progress Report 2-Summary. See Section 2.3.5.1 of Progress Report 2-Summary for objectives of mammalian predator studies.

2.3.5.2 Methods

No changes have been implemented since Progress Report 2-Summary. See Section 2.3.5.2 of Progress Report 2-Summary for methods used in mammalian predator studies.

2.3.5.3 Results

Records of tracks, scats, and other definitive signs recorded by ECI personnel on and near Tract C-a, as well as the results of the siren census and scent-station visitation survey, indicate the coyote (*Canis latrans*) and the weasel (*Mustila* sp.) were the most abundant mammalian predators in Tract C-a area during the October sampling period.

2.3.6 Winter Tract Counts

Winter track count data were not collected during the reporting quarter.

2.3.7 Avifauna

2.3.7.1 Objectives

No change has occurred since Progress Report 2-Summary. See Section 2.3.7.1 of Progress Report 2-Summary for objectives of avifauna studies.

2.3.7.2 Methods

No changes have been implemented since Progress Report 4-Summary. See Section 2.3.7.2 of Progress Report 4-Summary for methods used in avifauna studies.

2.3.7.3 Results

The largest number of birds and the greatest number of species encountered during the two fall (1974 and 1975) sampling periods occurred within the rabbitbrush, greasewood/sagebrush, Douglas-fir, and riparian vegetation types. The pinyon-juniper (south slope), mixed brush (north slope), upland meadow, and sagebrush (flat) types exhibited a paucity of species and low total numbers of birds during October 1974 and 1975. The mountain bluebird, mountain chickadee, gray-headed junco, dark-eyed junco, horned lark, white-crowned sparrow, and yellow-rumped warbler were observed in greater numbers than any other species during the autumn surveys.

The October 1974 sampling period probably occurred near the end of the fall migration for most bird species. Some migrating birds such as the mountain bluebird, western meadowlark, and white-crowned sparrow were still present in the study area. A greater number of summer resident species was present during the October, 1975 census period than during the October, 1974 period. The mild fall weather that occurred during 1975 probably resulted in later migratory exodus in comparison with the 1974 fall migration.

Migratory species encountered in October had departed the area of investigation by winter, while more northern migratory species such as the northern shrike and tree sparrow had migrated into the region after the fall sampling period.

Any census of avian species during a transition stage (such as October 1975) must be analyzed with caution. During these transitory periods, species migrating in flocks tend to move along certain topographic features such as a drainage, river valley, canyon, etc. Species comprising these flocks generally display a less specific attachment to favored habitat than they exhibit during the breeding season. The uneven distributional pattern of avian species in large areas of favored habitat can further be explained by inclement weather and the tendency for species to form large intermixed flocks during migration.

On an annual basis, the riparian community and adjacent habitats supported the greatest bird density and diversity throughout the year, while the sagebrush and rabbitbrush communities supported the lowest number of species and individuals.

In the Tract C-a vicinity, a few surface ponds and intermittent streams create isolated islands of habitat for waterfowl and shorebirds. Because surface water is restricted in distribution in northwestern Colorado, such habitat types have an unusually high ecological value in this region. Fourteen waterfowl and shorebird species were recorded within the Tract C-a vicinity. Although usage of the area by waterfowl and shorebirds is greater during late spring and summer than during fall, the overall waterbird population within the study area is small. The scarcity of open water is undoubtedly a major limiting factor on the size of the resident and migratory waterfowl populations. The mallard, green-winged teal, blue-winged teal, killdeer, and common snipe were the most common waterfowl and shorebirds utilizing surface waters of the area.

The distribution of raptors observed during the aerial surveys demonstrated a number of interesting trends. The majority of raptors were recorded within the eastern half of the study area, along the drainages. Observed raptors were the raven, rough-legged hawk, and golden eagle. Aerial surveys were not conducive for sightings of small, low-flying raptors such as accipiters and falcons. The few small, low-flying raptors recorded during aerial surveys were thus not a fair indication of the relative abundance of these birds of prey on the study area. Fourteen diurnal and four nocturnal raptors were encountered between October 1974 and October 1975. The red-tailed hawk was frequently observed during all times of the year except during the late winter sampling period. The rough-legged hawk was the most common wintering raptor. This species breeds on the arctic tundra, so it was not present during summer. The golden eagle was observed frequently throughout the year. A greater number of golden eagle observations occurred during winter than during other seasons, suggestive of a winter concentration in the Piceance Basin. The marsh hawk and American kestrel were recorded during the winter. The common raven was the species recorded most frequently throughout the year; it was present in all vegetation types within the study area. Other diurnal raptors observed less frequently were the turkey vulture, goshawk, sharp-shinned hawk, Cooper's hawk, Swainson's hawk, bald eagle, prairie falcon, merlin, and peregrine falcon.

2.3.8 Reptiles and Amphibians

Reptile and amphibian data were not collected during the reporting quarter.

2.3.9 Terrestrial Invertebrates

2.3.9.1 Objectives

No changes have been implemented since Progress Report 4-Summary. See Section 2.3.9.1 of Progress Report 4-Summary for the objectives of the invertebrate studies.

2.3.9.2 Methods

No changes have been implemented since Progress Report 4-Summary. See Section 2.3.9.2 of Progress Report 4-Summary for methods used in invertebrate studies.

2.3.9.3 Results

Seven different methods (pitfalls, litter D-vac, trap D-vac, herbaceous sweeps, beating, and ground and aerial surveys) were employed to sample invertebrates both quantitatively and qualitatively at five sites, each in a different vegetation type during September, 1975.

September 1975 results for the five habitat types sampled showed lower total captures in all of the strata sampled relative to June and July samples. Ground-dwelling fauna were most abundant in the litter in September, but very scarce on the surface. A variety of samples from the vegetation indicated that the herbaceous vegetation supported the largest invertebrate fauna at all but the two sagebrush habitats. Invertebrate captures from shrubs were numerically smaller in September on all but the two species sampled in the mixed brush. Captures of active flying species at all sites were down substantially in September from those recorded in July.

The unknown feeding habit comprised the majority of the captures of ground-dwelling invertebrates at nearly all sites in September. This was due to the relative abundance of mites in most cases. In samples taken from all types of vegetation, herbivores were consistantly the numerically dominant group.

2.3.10 Domestic Livestock

2.3.10.1 Objectives

No changes have been implemented since Progress Report 4-Summary. See Section 2.3.10.1 in Progress Report 4-Summary for the objectives of domestic livestock studies.

2.3.10.2 Methods

No changes have been implemented since Progress Report 4-Summary. See Section 2.3.10.2 in Progress Report 4-Summary for methods used in domestic livestock studies.

2.3.10.3 Results

Aerial surveys were conducted on November 6 and 24, 1975. During the November 6 survey, 500 cattle were observed; large numbers of cattle were observed on 84 Mesa, Duck Creek, Ryan Gulch and Wagon Road Ridge. The cattle were scattered in small groups throughout the study area. On the November 24 survey, cattle were more frequently observed in the bottoms of Ryan Gulch, Yellow Creek, Corral Gulch and Duck Creek than on the associated ridges and mesas as observed during the previous survey. Five hundred eighty-four cattle were observed during the November 24, 1975 survey.

2.3.11 Remote Sensing

2.3.11.1 Objectives

No changes have been implemented since Progress Report 4-Summary. See Section 2.3.11.1 of Progress Report 4-Summary for objectives of the remote sensing program.

2.3.11.2 Methods

No changes have been implemented since Progress Report 4-Summary. See Section 2.3.11.2 of Progress Report 4-Summary for methods used in remote sensing studies.

2.3.11.3 Results

One flight to obtain color infrared (CIR) imagery at a scale of 1:6000 was conducted in September, 1975. Coverage at the 1:6000 scale provided imagery of the entire 400 km^2 (170 sq mi) study area. The imagery has been arranged in flight lines for analysis.

2.3.12 Threatened and Endangered Species

2.3.12.1 Objectives

No changes have been implemented since Progress Report 4-Summary. See Section 2.3.12.1 in Progress Report 4-Summary for objectives of the threatened and endangered species studies.

2.3.12.2 Methods

No changes have been implemented since Progress Report 4-Summary. See Section 2.3.12.2 in Progress Report 4-Summary for methods used in threatened and endangered species studies.

2.3.12.3 Results

One prairie falcon was observed during the reporting quarter. However, it is undetermined whether this species nests within the study area.

The possible use of 84 Mesa as a fall staging area was investigated during September and October 1975. Two flocks of greater sandhill cranes were observed on 84 Mesa on October 25, 1975.

Greater sandhill cranes usually remain for 2-7 weeks at a fall staging area prior to their southward migration (Drewien and Bizeau, 1974). However, surveys of 84 Mesa that occurred on October 22 and November 4-6, 1975 during the peak of migration did not reveal greater sandhill cranes. Thus, the two flocks observed probably utilized 84 Mesa as a temporary resting and foraging area during their southward migration.

The status of the flock observed October 8, 1975 near the confluence of Piceance Creek and Ryan Gulch is unknown. Some cranes migrating southward from northern staging areas will occasionally stop at staging areas farther south (Drewien and Bizeau, 1974). Greater sandhill cranes generally require available grain in proximity to an adequate water supply for their fall staging area (Drewien and Bizeau, 1974), but 84 Mesa does not seem to meet these criteria. In the fall, greater sandhill cranes generally move to the major staging area nearest their summer nesting site. Reports from several residents in the White River and Piceance Creek concerning occasional sightings of cranes during past migration periods suggest that portions of the Piceance Creek Valley may serve as foraging sites for transient cranes. Thus, the flock observed on October 8, 1975 could have been either foraging and/or staging along Piceance Creek.

2.3.13 Range Analysis

2.3.13.1 Objectives

Range, browse, and soil condition and trend are the principal criteria influencing grazing management decisions on federally administered lands. Field studies have been undertaken in the area of Tract C-a in 1973 by the Bureau of Land Management.

This program was primarily designed to determine the range condition (the current condition of the range in relation to the potential of which the site is capable) of all circumscribed plant communities that have been mapped for Tract C-a and adjacent areas. Trend, the inclination of range condition toward improvement, stabilization or deterioration, was also determined. Concurrently, browse and soil conditions and trend were evaluated.

Since similar methodologies have been used, the condition and trend studies presented herein relate to and integrate with separate studies conducted by state and federal agencies. Data obtained during these studies permit practical evaluations affecting land management decisions.

2.3.13.2 Methods

The procedures used to establish vegetation condition and trend were consistent with common range analysis practices as described in detail in the United States Department of Agriculture Forest Handbook 2209.21R3 (Range Environmental Analysis Handbook, 1970). Maps on which vegetation types were delineated by remote sensing techniques were used to locate field sampling locations. Each circumscribed type was ground-checked and the dominant vegetation verified.

Each delineated vegetation type estimated to be greater than 16 ha (40 A) but smaller than one-half section (128 ha) in size was sampled by means of one paced transect. In larger types, transects were placed at an approximate rate of one per one-half section longitudinal to and centered within the shape of the type. A total of 137 transects, each 400 paces in length, were established. Sampling points along a transect were located at 4-step intervals for grass-forb data collection (100 sampling points) and at 16-step intervals for browse data collection (25 sampling points).

At each grass-forb sample point, a loop 1.91 cm (0.75 in.) in diameter was placed at a mark on the toe of a boot, and hits on rock, litter, bare soil, and vegetation were recorded on a standard field data form. Hits on vegetation were recorded by individual plant species. When the loop did not hit a perennial plant, the nearest plant within the 180° arc of the loop was tallied. Each plant, depending on its response to grazing or disturbance, was ecologically classified as a decreaser (desirable), increaser (intermediate), or invader (undesirable). These designations were checked and verified by Dr. Phil Sims of the Range Science Department, Colorado State University; Dr. Robert Hyde, a Colorado State University Range Extension specialist; and Mr. Tom K. Eamon, a Range Conservationist with the Denver Office of the Soil Conservation Service.

Plant vigor and current soil erosion, factors used in the range analysis, were visually evaluated and recorded. Vigor ratings were made only on available decreaser and increaser species and scored on a 0-10 scale.

The score was based on leaf length, number of seedstalks, and root system, which was correlated in size or extent to above-ground plant parts. Current soil erosion and vegetation and soil trends at each study site were determined visually.

At each browse sampling point, the nearest browse plant within a 180°arc of the loop was given an age and form class designation. These designations were based on criteria developed by Patton and Hall (1966).

2.3.13.3 Results

The study area covered approximately 35,269 acres and encompassed six major vegetation types: pinyon-juniper, sagebrush, mixed brush, upland meadow, aspen, Douglas-fir, and one associations of a major vegetation type, greasewood. These were distributed as follows: pinyon-juniper - 13,930 acres or 39.5% of the area; sagebrush - 11,853 acres or 33.6% of the area; mixed brush - 8,499 acres or 24.1% of the area; upland meadow - 496 acres or 1.4% of the area; aspen - 313 acres of 0.9% of the area; Douglas-fir - 115 acres or 0.3% of the area; and greasewood (variant of sagebrush vegetation type) - 63 acres or 0.2% of the area. The survey area was situated so as to encompass Tract C-a and the full spectrum of elevational zones and vegetation types which surround it.

The major proportion (73.1%) of the study area, 25,823 acres, was in "Fair" range condition category. Only 2.4%, or 846 acres, was classified in "Good" condition. Most of this, 631 acres, was in sagebrush communities; the remainder consisted of aspen and Douglas-fir vegetation types. A total of 8,609 acres or 24.4% of the area was placed in the "Poor" condition class. Pinyon-juniper (6,939 A) and sagebrush (1,643 A) sites contributed the largest proportions to this "Poor" condition class.

No sites were in either the "Excellent" or "Very Poor" condition classes. Few sites on the study area, however, have the potential for achieving the former condition. Range condition classification is predicated on the hypothesis that vegetation is a product of environment, subject to physical, edaphic, and biotic influences and limitations. Many western rangelands have never attained climax status because of one or more of these limitations. The great time involved to arrive at climax or "Excellent" condition precludes that condition from being a practical management objective (Stoddart and Smith, 1955).

The largest block, 48.5% or 17,100 acres, was placed in the category of upward or improving range trend. A majority of sites in all vegetation types except pinyon-juniper demonstrated upward trend. Sites totalling 2,886 acres or 8.18% of the area, exhibited stability or no apparent trend. The areas assigned a downward or deteriorating trend encompassed 15,291 acres or 43.4% of the total. The greatest proportion of deteriorating rangelands (12,801 acres) were in the pinyon-juniper vegetation type.

Browse condition studies consider only three possible condition classes - good, fair, and poor. Browse condition was determined to be almost entirely (98.4%) within the "Good" condition class. The area encompassed by this category comprised 34,219 acres. A collective area of sites totalling 482 acres, 1.4% of the area, was placed in the "Fair" condition class. Only 73 acres, 0.20% of the area, was judged to be in "Poor" condition.

Most of the browse was in good condition, however, 59.7% or 20.756 acres, exhibited a deteriorating or downward trend. An area about one-half that size, 10,435 acres or 30.0% of the acreage, showed no apparent trend.

Range condition classed can be described conceptually as stages of plant community succession or retrogression, resulting from physical, edaphic, and biotic interactions. The latter category includes the grazing impacts of domestic livestock, feral horses, big game, and smaller herbivores, and is the most amenable to manipulation my man.

In 1971, the Cathedral Bluffs Grazing Unit was divided into individual grazing allotments. Management plans to ensure more efficient utilization of forage and a more balanced allocation of that resource were implemented by the BLM on the Square S and Reagle Allotments four years ago (personal communication, November, 1975, Stan Colby, Bill Lawthorne, Meeker BLM Office). Ranchers interviewed in the area believe that local ranges have been improving gradually for the past several years and looked better this past season than at any time in recent years. Mule deer, which utilize the area for winter and transitional ranges, have decreased drastically since the 1950's (personal communication, 1975, Colorado Division of Wildlife). Given these circumstances, a recovery in range condition might be reasonably expected.

Browse conditions on the study area were overwhelmingly in the "Good" condition class. The largest portion, however, was seen to exhibit downward trend, or a deterioration in condition. Mule deer use the area primarily as transitional range except in mild winters, a fact which is reflected in the favorable condition which prevails. The evidence that browse conditions are deteriorating may correspond to increases in feral horse numbers or edaphic changes. These animals use the area year-round and utilize the browse species heavily when snow depths retard access to preferred herbaceous species.

2.3.14 Range Production-Utilization

2.3.14.1 Objectives

Range production and utilization studies were undertaken to measure the actual forage being produced annually per unit area within each major association. The amount of forage taken by large herbivores at a given point in time is also measured. These studies will reveal the relative preferences of herbivores for particular plant associations.

2.3.14.2 Methods

Grass and forb production utilization studies were conducted within four principal vegetation types: Pinyon-juniper, sagebrush, mixed brush and grass balds. Annual forage production figures were obtained by late summer clippings of .89 m^2 (9.6 sq ft) plots which have been protected through the growing season by conical 5 cm x 10 cm (1.95 in x 3.9 in) mesh welded wire cages. Sixty-six cages were distributed within different vegetation types throughout the study area. The locations of these cages corresponded to the locations of certain previously established vegetation transects for phytosociological studies.

Shadscale, rabbitbrush, greasewood, Douglas-fir, aspen, and riparian sites were not sampled due to the relatively minor contribution these vegetation types make to total productivity in the study area.

After completion of the growing season in late August or early September, forage utilization was measured by comparing clippings from plots which were protected from grazing with clippings from plots which were unprotected. A grazed (unprotected) plot was located near each caged plot by using the second hand of the observer's watch to determine direction, and a random numbers table to determine distance in paces. Forage in the unprotected plot was clipped and weighed; all samples were marked with the location and date of collection. Ocular estimates of forage production were made concurrently to supplement this method.

All clipped samples were returned to the ECI laboratory, oven-dried at 70°C for at least 24 hours in a Thelco oven, and weighed again to provide dry weight estimates.

2.3.14.3 Results

Production varied widely over the study area from a mean of 92.86 pounds/acre (104.93 kilograms/hectare) on pinyon-juniper sites to 240.00 pounds/acre (271.20 kilograms/hectare) on mixed brush sites. Sites located in the sagebrush vegetation type produced an average 185.00 pounds/acre (209.62 kilograms/hectare) and upland meadow sites produced 173.00 pounds/acre (195.49 kilograms/hectare).

These figures compare unfavorably with Soil Conservation Service (SCS, 1975) estimates of range site production potentials for northwestern Colorado. This discrepancy may be due to techniques utilized. The "Stoney Foothills Range Site", which corresponds to most area pinyon-juniper vegetation types, is capable of producing 400-800 pounds of air-dry forage per acre. The "Mountain Loam and Loamy Slopes Range Sites", which encompass the mixed brush types, have been given production potentials of 1200-1800 and 500-1200 pounds/acre, respectively. The "Clayey Foothills Range Site", corresponding to many study area sagebrush vegetation type sites, has a production potential of 600-1200 pounds/acre. The SCS "Dry Exclosure Range Site" corresponds to the upland meadow vegetation type and has a production potential of 500-650 pounds/acre.

Utilization studies were undertaken concurrently with productivity studies. Such studies would normally be conducted at the conclusion of the grazing season, but there is year-round grazing in the study area. Cattle use the area until they are excluded by a permanent snowpack. Feral horses remain there all year, pawing through snow to obtain the remaining forage. The end of the growing season, approximately the beginning of September, was selected as the sampling period since the time was optimum for productivity clipping. Because of aforementioned conditions, there is no optimum time for obtaining utilization measurements. Those that follow should be interpreted as relative indices of herbivore utilization on the various vegetation types through completion of the growing season, but not as total annual utilization.

Utilization ranged from 7% on sagebrush sites to 43% on upland meadow sites. Mixed brush sites had 41% of total forage production utilized and pinyon-juniper sites received 24% utilization.

Forage production was well below minimal Soil Conservation Service (SCS) expectations (SCS, 1975) for range sites included in the study area during unfavorable years. Precipitation was submormal this past year (personal communication, November, 1975, Greg Cresswell, EE&G - information obtained from compilation of weather records from Rifle, Meeker, and Rangely, Colorado), but not sufficiently subnormal to account for the low production. Pinyon-juniper sites were the lowest producing ranges while mixed brush vegetation type produced the highest amount of forage.

Productivity is highly correlated with the increased precipitation occurring at higher elevations. The upland meadow sites, however, are swept clean of winter snow accumulations by high velocity winds and so do not receive the benefit of precipitation occurring as snow. Aerial surveys have revealed that these areas are utilized heavily in the winter by feral horses. The mixed brush vegetation type exhibited the greatest productivity because of deeper soils (with the exception of bottomland sage stands on alluvial deposits) and the most favorable moisture conditions. The pinyon-juniper sites were the least productive due to the shallow soils, lesser annual precipitation, and competition for soil moisture between forage and canopy species. The fact that feral horses and mule deer concentrate in these sites during the winter months to seek respite from chilling winds and temperatures contributes to the conditions which prevail there. The sagebrush vegetation type was the most variable since no distinction was made between upland and bottomland sites. Bottomland sites on deep alluvial deposits, where great basin wildrye (Elymus cinereus) was dominant, were highly productive, whereas some upland sites were almost void of a grass-forb understory. These differences were attributed to variations in soil depth, and soil moisture competition.

By early September, utilization was directly related to elevational zonations. Heaviest use occurred on the upland meadow sites (the bald areas atop the highest ridges in the study area). The next heaviest use was found in the mixed brush vegetation type, which occurs primarily in the next lower elevational zone. Intermediate use was seen in the pinyon-juniper vegetation type. Lowest utilization was found on the lower occurring sagebrush vegetation types.

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2.4 Aquatic Studies

The Aquatic Baseline Data Accumulation Program is intended to perform those environmental studies described in the Federal Register, Volume 39, Number 230, Part 3, Oil Shale Lease Environmental Stipulations and in the Tract C-a Exploratory plan of May 1974. Specific lease requirements addressed were "The Lessee shall make studies of the flora and fauna . . . and also of the aquatic habitat as far downstream as the Mining Supervisor shall require." "The Lessee shall compile an inventory of natural surface features, such as springs and seeps."

No detailed studies of the aquatic ecosystems of Tract C-a have been made prior to the present baseline study. However, studies of similar habitats indicate that the composition and abundance of the aquatic flora and fauna are primarily determined by the permanency of flow.

The overall objective for the Aquatic Baseline Data Accumulation Program is to characterize the existing aquatic communities on and in the vicinity of Tract C-a. These studies will inventory aquatic habitats which may be affected by oil shale development. The ongoing programs are summarized in Table 2.4-1.

In order to fulfill these objectives, 35 sampling stations have been selected to represent the aquatic habitats present. Emphasis has been placed on Yellow Creek and the White River which are permanently flowing streams. The locations of aquatic sampling stations are depicted in Figure 2.4-1. Sampling periods discussed herein are July - August and August - September 1975. The condition (dry or flowing) of each station during this period and dates on which aquatic samples were taken during July - August and August - September are shown in Table 2.4-2. Physical, chemical, and biological measurements are taken concurrently at each sampling site.

2.4.1 Physical and Chemical Characteristics

2.4.1.1 Objectives

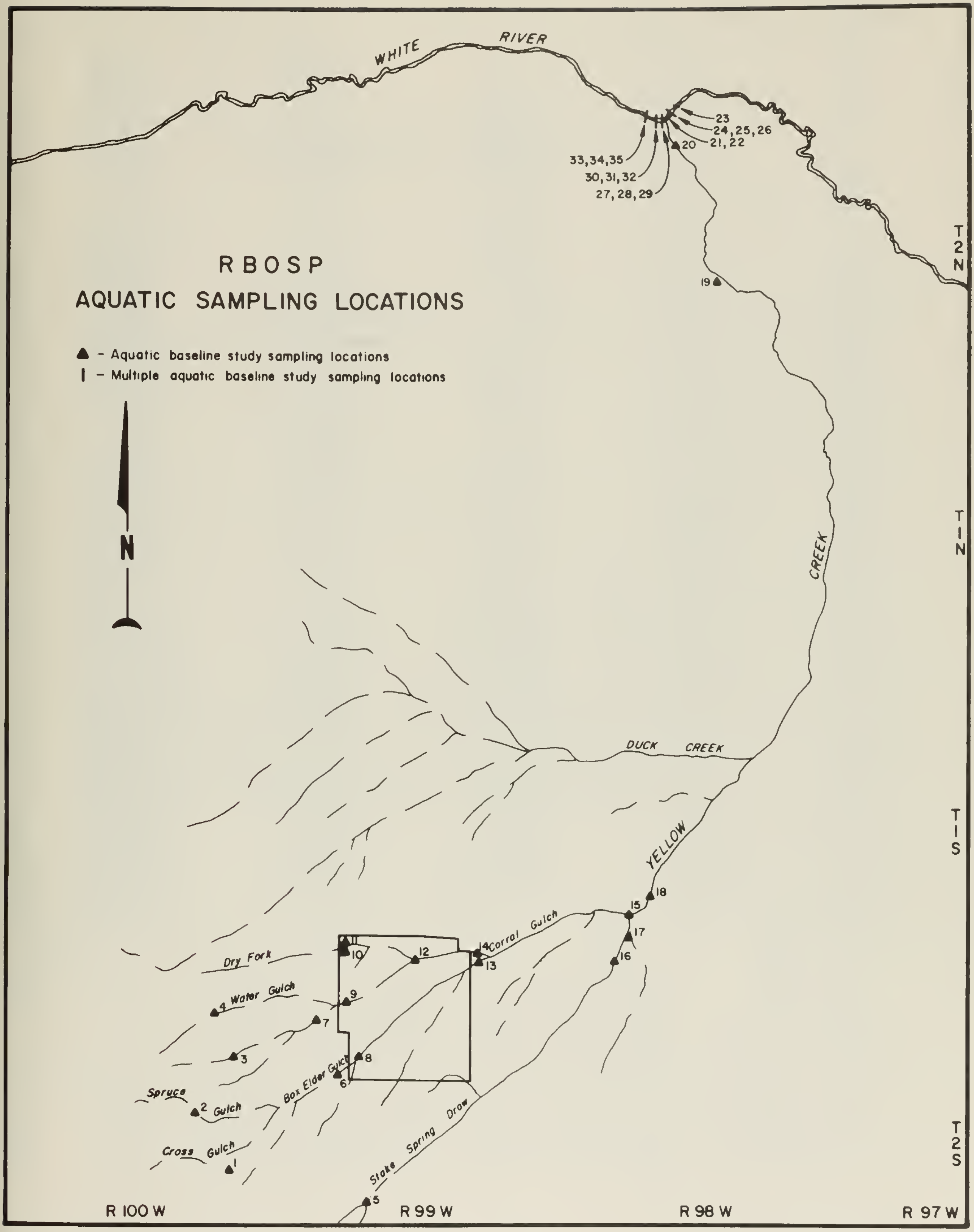
No change in objectives has occurred since Progress Report 3 - Summary. See section 2.4.1.1 of Progress Report 3 - Summary for specific objectives.

2.4.1.2 Methods

No change in methods has occurred since Progress Report 3 - Summary. See section 2.4.1.2 of Summary Progress Reports 2 and 3 for specific methods used in measuring the physical and chemical characteristics of the waters under study. See Table 2.4-3 for specific analytical methods.

Table 2.4-1. Summary of RBOSP Aqautic Sampling Programs July - August and August - September 1975.

Group Sampled	Objective	Methodology	No. of Sample Sites July-Aug.	Aug.-Sept.
Physical measurements	To measure existing physical parameters	Flow, O_2, pH, Cond., and temp. meters	30	29
Water Chemistry	Analysis of certain chemical characteristics of particular biological significance	Pump-type or bottle-type	30	29
Phytoplankton	Population studies and species inventory	Pump-type or bottle-type	30	29
Zooplankton	Population studies and species inventory	Wisconsin nets w/flow meter or pump	30	29
Periphyton	To estimate abundance determine biomass and productivity	Scraped off rock	30	29
Benthos	Population studies and species inventory	Ekman, modified Surber, D-frame	30	29
Macrophytes	Species inventory	Random transect	30	29
Fish	Population studies, species inventory, condition, food habits	Electrofishing/ seining	15	15
Sediment chemistry	To measure existing chemical characteristics		30	29
Rare and endangered species			Opportunistic	
Spring & seeps			Opportunistic	
Water quality	To measure existing water quality in the White River near Yellow Creek			2



RBOSP
AQUATIC SAMPLING LOCATIONS

▲ - Aquatic baseline study sampling locations
| - Multiple aquatic baseline study sampling locations

Table 2.4-2. Dates of sampling for RBOSP Aquatic Baseline Studies. July - August and August - September 1975.

Station	Date Sampled	Flow Condition	Date Sampled	Flow Condition
1	7-18-75	Flowing	8-29-75	Flowing
2	7-18-75	Flowing	8-29-75	Flowing
3	7-17-75	Flowing	8-20-75	Flowing
4	7-17-75	Flowing	8-20-75	Flowing
5	7-21-75	Flowing	8-25-75	Flowing
6	7-15-75	Dry	8-22-75	Dry
7	7-15-75	Flowing	8-22-75	Flowing
8	7-15-75	Flowing	8-22-75	Flowing
9	7-15-75	Flowing	8-22-75	Flowing
10	7-15-75	Dry	8-22-75	Dry
11	7-15-75	Dry	8-22-75	Dry
12	7-15-75	Dry	8-28-75	Flowing
13	7-15-75	Flowing	8-25-75	Flowing
14	7-21-75	Flowing	8-25-75	Flowing
15	7-21-75	Flowing	8-28-75	Dry
16	7-15-75	Dry	8-25-75	Dry
17	7-21-75	Flowing	8-28-75	Flowing
18	7-16-75	Flowing	8-28-75	Dry
19	8-06-75	Flowing	8-21-75	Flowing
20	8-05-75	Flowing	9-02-75	Flowing
21	8-05-75	Flowing	9-02-75	Flowing
22	8-06-75	Flowing	9-02-75	Flowing
23	8-01-75	Flowing	9-09-75	Flowing
24	7-28-75	Flowing	9-04-75	Flowing
25	7-28-75	Flowing	9-04-75	Flowing
26	7-28-75	Flowing	9-04-75	Flowing
27	7-31-75	Flowing	9-05-75	Flowing
28	8-01-75	Flowing	9-05-75	Flowing
29	7-31-75	Flowing	9-05-75	Flowing
30	7-29-75	Flowing	9-03-75	Flowing
31	7-29-75	Flowing	9-03-75	Flowing
32	7-29-75	Flowing	9-03-75	Flowing
33	7-30-75	Flowing	9-08-75	Flowing
34	7-30-75	Flowing	9-08-75	Flowing
35	7-30-75	Flowing	9-08-75	Flowing

Table 2.4-3. Water and sediment chemistry, Analytical Laboratory Methodology. RBOSP Aquatic Baseline Studies.

Parameter	Measurement Methodology[1]	Detection Limit (ppm)[2]	Sample Preservation
	WATER CHEMISTRY		
Alkalinity, total	Colorimetric	2	None required
Ammonia nitrogen	Electrode	0.10	$HgCl_2$
Calcium, dissolved	Atomic absorption	0.02	None required
Chloride, dissolved	Potentiometric	0.4	None required
Hardness, total	EDTA Titration	2	None required
Magnesium, dissolved	Atomic absorption	0.005	HCl
Kjeldahl nitrogen	Kjeldahl digestion	0.10	$HgCl_2$
Nitrate, dissolved	Brucine	0.2	$HgCl_2$
Nitrite, dissolved	Diazotization	0.01	$HgCl_2$
Phosphate, ortho (dissolved)	Ammonium molybdate - potassium antimonyl tartrate	0.01	$HgCl_2$
Phosphate, total	Same as orthophosphate	0.01	$HgCl_2$
Potassium, dissolved	Atomic absorption	0.1	HCl
Silica, dissolved	Molybdosilicate	0.005	HCl
Sodium, dissolved	Atomic absorption	0.005	HCl
Sulfate, dissolved	Gravimetric	3	Refrigeration
Carbon, dissolved organic	Beckman TOC Analyzer	2	HCl
Carbon, total organic	Beckman TOC Analyzer	2	HCl
Solids, suspended	Filtration	1	None required
Solids, total dissolved	Filtration and evaporation	1	None required

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[1] Methods are those specified in the Federal Register, Vol. 38, No. 199, Oct. 16, 1973, except for use of specific ion electrode.

[2] For water samples, this detection limit is the minimum concentration which will be reported on natural and treated water samples (99.99% H_2O) with the indicated method and using a sample of definite size.

Table 2.4-3. (Continued)

Parameter	Measurement Methodology	Detection Limit (ppm)	Sample Preservation
	SEDIMENT CHEMISTRY[3]		
Arsenic	Extraction and Atomic absorption	1	Refrigeration
Aluminum	Extraction and Atomic absorption	10	Refrigeration
Herbicide	Gas Chromatography	100ppb	Refrigeration
Lead	Extraction and Atomic absorption	0.5	Refrigeration
Mercury	Extraction and Atomic absorption	0.02	Refrigeration
Nitrogen, total Kjeldahl	Kjeldahl digestion - Electrode	10	Refrigeration
Phosphate, total	Persulfate digestion	0.25	Refrigeration
Solids, total volatile	Filtration, evaporation volatilization	10	Refrigeration
Zinc	Extraction and Atomic absorption	0.5	Refrigeration

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[3] Detection limits vary with sample size.

2.4.1.3 Results

During the July - August 1975 sampling period a total of five sampling sites was dry; the dry sites included Stations 6, 10, 11, 12, and 16. During the August - September sampling period, the dry sites included Stations 6, 10, 11, 15, 16, and 18.

A summary of selected parameters for the White River and Yellow Creek stations is presented below.

July - August

Parameter	White River		Yellow Creek	
	low	high	low	high
Specific conductance (μmhos)	625	1250	2600	3900
pH	8.1	8.2	8.4	8.7
Alkalinity, total ($CaCO_3$) mg/l	185	486	650	145[illegible]
Chloride (mg/l)	21	92	32	177
Sulfate (mg/l)	36	42	160	280
Dissolved solids (mg/l)	365	417	1920	2580
Turbidity (JTU)	10	35	7	25
Dissolved oxygen (mg/l)	7.8	8.7	8.1	12.3
Temperature (°C)	18	21	16	22

August - September

Parameter	White River		Yellow Creek	
	low	high	low	high
Specific conductance (μmhos)	775	2500	2800	4100
pH	8.2	8.6	8.2	8.7
Alkalinity, total (CaCO mg/l)	206	422	748	1858
Chloride (mg/l)	29	44	29	169
Sulfate (mg/l)	46	59	135	297
Dissolved solids (mg/l)	485	822	1900	3500
Turbidity (JTU)	10	35	20	40
Dissolved oxygen (mg/l)	9.2	10.9	7.2	14.2
Temperature (°C)	15	18	16	25

The physical and chemical data collected from stations on the White River (Stations 23-35) and from those on Yellow Creek (Stations 19-22) are comparable during the two sampling periods. The high extremes of conductivity (3900 and 4100 μmhos) indicated in the tables above occurred at Station 28 near the mouth of Yellow Creek. The data are generally within the ranges of concentration reported by the U.S. Geological Survey (1971, 1972, 1973) and by Everhart and May (1973).

2.4.2 Phytoplankton

2.4.2.1 Objectives

No change in objectives has occurred since Progress Report 3 - Summary. See section 2.4.2.1 of that report for specific objectives.

2.4.2.2 Methods

No change in methods has occurred since Progress Report 2 - Summary. See section 2.4.2.2 of that report for specific objectives.

2.4.2.3 Results

A total of 133 taxa was identified from samples collected during July - August 1975. During the July - August 1975 sampling, the Chrysophyta and Cyanophyta were the most abundant algal groups at all stations other than those in the White River. The most abundant species at the Headwater stations included the diatoms *Achnanthes minutissima*, and several species of the genera *Navicula* and *Nitzschia*. *Achnanthes minutissima* and several species of *Nitzschia* also dominated the phytoplankton on or near Tract C-a. At Yellow Creek stations, the most abundant taxa were the diatoms *Cyclotella meneghiniana* and *Navicula viridula*. As found in previous months, the phytoplankton abundance at Station 19 was lower than at the other Yellow Creek stations. The Chrysophyta also dominated the algal community in the White River. The diatoms *Synedra ulna* and *Nitzschia holsatica* and an unidentified green flagellate were the most abundant taxa.

A total of 123 taxa was identified from the August - September phytoplankton collections. The dominant algal taxa at the Headwater stations varied among the stations. The algal flora at Station 1 was dominated by *Navicula arvensis* and *Achnanthes minutissima*. *Achnanthes minutissima* and *Synedra minuscula* were the most abundant algal taxa at Station 2. The most abundant algal taxa at Stations 3 and 4 were *Navicula cryptocephala* and *Nitzschia palea* whereas at Station 5 *Cocconeis pediculus* was most abundant. During the August - September sampling, phytoplankton abundance at the Tract stations was evenly distributed among the major algal division than at any other time during the first year of study. The phytoplankton of the Tract stations were dominated by *Achnanthes minutissima*, *Navicula crytocephala* and *Navicula capitellata*. *Cyclotella meneghiniana*, *Nitzschia frustulum* and *Nitzschia latens* were the dominant algal taxa at Yellow Creek.

stations. As in previous months, densities were relatively low in Yellow Creek. Dominant algal taxa at the White River stations include Epithemia sorex and Nitzschia frustulum.

2.4.3 Zooplankton

2.4.3.1 Objectives

No change in objectives has occurred since Progress Report 2 - Summary. See section 2.4.3.1 of that report for specific objectives.

2.4.3.2 Methods

In accordance with the revised aquatic Scope of Work of April 2, 1975 zooplankton samples are taken with a small submersible pump at all stations. Other methods remain unchanged from Progress Report 2 - Summary. See section 2.4.3.2 of that report for specific methods.

2.4.3.3 Results

A total of 74 zooplankton taxa was observed in the two July - August 1975 replicate collections. Data from the second replicate are very similar to data previously reported in Progress Report 3 - Summary. Centropyxis species, unidentified bdelloid rotifers and ostracods were the most abundant taxa at the Headwater stations above Tract C-a. The zooplankton fauna on or near the tract was dominated by Centropyxis, Vorticella sp., Euchlanis dilatata, Crustacea nauplii and unidentified monogonont rotifers. Centropyxis species and unidentified monogonont rotifers were also the dominant taxa at Yellow Creek and White River stations.

A total of 52 taxa was observed in replicate samples from the August - September collection. The composition of the zooplankton in the August - September collections was clearly influenced by habitat. The zooplankton of the spring brook stations of both the Headwater and Tract areas were dominated by Centropyxis and by either Vorticella sp. and Crustacea nauplii or ostracods. However, a high diversity of both rotifers and Crustacea was observed at stations located on or below ponds (Stations 5, 14, and 19) and at Stations 20 - 22 on Yellow Creek. The most abundant taxa included Euchlanis dilatata, Lepadella patella, Monostyla closterocerca and unidentified monogonont rotifers. The Crustacea fauna at Station 14 differed considerably from that at the other stations. Ceriodaphnia quadrangula were the dominant species at Station 14, whereas, at other stations, the most abundant Crustacea taxa included Alona circumfimbriata, *Pleuroxus aduncus* and *Eucyclops agilis*. The White River zooplankton was dominated by *Centropyxis* species, unidentified monogonont rotifers and *Epistylis* sp.

2.4.4 Periphyton

2.4.4.1 Objectives

No change in objectives has occurred since Progress Report 2 - Summary. See section 2.4.4.1 of that report for specific objectives.

2.4.4.2 Methods

No change in methods has occurred since Progress Report 2 - Summary. See section 2.4.4.2 of Summary Progress Reports 2 and 3 for specific methods.

2.4.4.3 Results

A total of 65 algal taxa was observed in the July - August 1975 collection. Periphytic algal densities were low at Headwater stations in July - August. *Achnanthes minutissima* and *Bicoeca lacustris* were the most abundant species. *Achnanthes minutissima* and *Nitzschia denticula* were the most abundant at the Tract stations.

Each of the Lower Yellow Creek stations had different major abundant species during the July - August 1975 sampling. At Station 19, *Navicula cryptocephala* and *Nitzschia fonticola* were most abundant. Station 20 had low algal densities and *Navicula pelliculosa*, *Navicula cryptocephala* and *Nitzschia fonticola* were most abundant. *Lyngbya* spp., *Nitzschia fonticola*, *Achnanthes minutissima*, and *Amphora ovalis* var. *pediculus* were most abundant at Station 21. *Navicula pelliculosa* was ten times more abundant than any other species at Station 22.

The most abundant algal taxa at the White River stations include *Lyngbya* spp. and *Amphora ovalis* var. *pediculus*.

A total of 61 algal taxa was found in the periphyton collection during the August - September 1975 sampling period. In August - September *Achnanthes minutissima* dominated the periphyton at almost all stations other than those in the White River. At Station 1, a Headwater station, *Bicoeca lacustris* was most abundant. *Epithemia sorex* was the most abundant species at White River stations.

2.4.5 Benthos

2.4.5.1 Objectives

No change in objectives has occurred since Progress Report 2 - Summary. See section 2.4.5.1 of that report for specific objectives.

2.4.5.2 Methods

The methods reported in section 2.4.5.2 of Summary Progress Reports 2 and 3 remain unchanged, with the exception that the D-frame net was utilized at Station 25 during both July - August and August - September 1975 sampling of the White River. See section 2.4.5.2 of Summary Progress Reports 2 and 3 for specific methods used in benthos sampling and analysis.

2.4.5.3 Results

A total of 120 benthic taxa was observed in samples taken during July - August 1975. The taxa are listed in Table 2.4-4. At the Headwater Stations 1 - 4, the most abundant taxa included Chironomidae, Baetidae and Simuliidae. The most abundant taxa observed at Station 5 included Nematoda, Oligochaeta, Amphipoda, Ceratopogonidae, Chironomidae and Simuliidae. The dominant taxa at Tract stations belonged to the Baetidae, Chironomidae and Simuliidae. In Yellow Creek, Oligochaeta and Ceratopogonidae were the most abundant taxa with Amphipods also very abundant at Station 19. The White River benthic fauna was dominated by the Oligochaeta, Chironomidae and Hydropsychidae.

A total of 107 benthic taxa was observed in the August - September 1975 collections. The most abundant taxa at the Headwater Stations 1 - 4 in August - September included Chironomidae, Simuliidae, Baetidae, Stratiomyidae and Plecoptera. The benthos at Station 5 was dominated by Oligochaeta, Nematoda, Ceratopogonidae, Chironomidae, Plecoptera and Simuliidae. Low densities were observed at the lower Yellow Creek stations with the Chironomidae the most abundant taxa. At Station 19 the Gastropoda, Oligochaeta, Ceratopogonidae and Simuliidae were most abundant. Oligochaeta, Ephemeroptera, Hychropsychidae and Chironomidae dominated the benthos in the White River.

2.4.6 Sediment Chemistry

2.4.6.1 Objectives

The objectives of the sediment chemistry studies remain unchanged from Progress Report 2 - Summary. See section 2.4.6.1 of Progress Report 2 - Summary for specific objectives.

Table 2.4-4. Macroinvertebrate taxa observed during RBOSP Aquatic Baseline Studies, July - August 1975.

- CNIDARIA
  - Hydrozoa
    - Hydroida
      - Hydridae
        - *Hydra* sp.

- NEMATODA

- MOLLUSCA
  - Gastropoda
    - Basommatophora
      - Hymnaeidae
        - *Lymnaea* sp.
      - Physidae
        - Unidentified
      - Planorbidae
        - Unidentified

- ANNELIDA
  - Hirudinea
    - Rhynchobdellida
      - Glossiphoniidae
        - *Helobdella stagnalis*
  - Oligochaeta
    - Haplotaxida
      - Enchytraeidae
      - Tubificidae
        - Unidentified sp. 1
        - *Ilyodrilus templetoni*
        - *Limnodrilus hoffmeisteri typical*
        - *Limnodrilus profundicula*
        - *Limnodrilus udekemianus*
        - *Rhyacodrilinae* sp.
        - *Rhyacodrilinae* sp. 1
        - *Tubifex tubifex*
        - Immatures with Cap. Chaetae sp.
        - Immatures without cap. chaetae sp.
      - Naididae
        - *Nais* sp.
        - *Nais behningi*
    - Lumbriculida
      - Lumbriculidae
        - Unidentified

- ARTHROPODA
  - Arachnoidea
    - Acari
  - Crustacea
    - Amphipoda

Table 2.4-4. (Continued)

- Talitridae
  - *Hyalella azteca*
- Insecta
  - Ephemeroptera
    - Baetidae
      - Unidentified larvae
      - *Baetis* sp. larvae
      - *Callibaetis* sp.
    - Heptageniidae
      - *Rhithrogena* sp.
    - Leptophlebiidae
      - Unidentified
    - Ephemerellidae
      - *Ephemerella* sp.
    - Tricorythidae
      - *Tricorythodes* sp.
    - Caenidae
      - *Caenis* sp.
  - Odonata
    - Zygoptera
      - Coenagrionidae
        - Unidentified
        - *Argia* sp.
    - Anisoptera
      - Gomphidae
        - Unidentified
  - Plecoptera
    - Unidentified
  - Hemiptera
    - Gerridae
      - *Gerris* sp.
    - Corixidae
      - *Cenocorixa* sp.
      - *Corisella tarsalis*
  - Coleoptera
    - Unidentified
    - Gyrinidae
      - Unidentified
    - Haliplidae
      - Unidentified
    - Dytiscidae
      - Unidentified
      - *Agabus* sp.
      - *Deronectes* sp.
      - *Rhantus* sp.
      - *Oreodytes* sp.
    - Hydrophilidae
      - Unidentified

Table 2.4-4. (Continued)

- Elmidae
    - Unidentified
    - *Dubiraphia* sp.
- Trichoptera
    - Unidentified
    - Hydropsychidae
        - Unidentified
        - *Hydropsyche* sp.
        - *Cheumatopsyche* sp.
    - Hydroptilidae
        - Unidentified
        - *Hydroptila* sp.
    - Limnephilidae
        - Unidentified
    - Leptoceridae
        - Unidentified
    - Brachycentridae
        - Unidentified
        - *Brachycentrus* sp.
- Lepidoptera
    - Pyralidae
        - Unidentified
- Diptera
    - Unidentified
    - Tipulidae
        - Unidentified
        - *Dicranota* sp.
        - *Limnophila* sp.
        - *Holorusia* sp.
    - Psychodidae
        - Unidentified
    - Ceratopogonidae
        - Unidentified
    - Chironomidae
        - Unidentified
        - Tanypodinae
            - Unidentified
            - *Ablabesmyia* sp.
            - *Labrundinia* sp.
            - *Larsia* sp.
            - *Procladius* sp.
            - *Psectrotanypus* sp.
            - *Thienemannimyia* group sp.
        - Diamesinae
            - *Diamesinae* sp. 1
            - *Diamesa* sp.
            - *Monodiamesa* sp.
            - *Pseudodiamesa pertinax*

Table 2.4-4. (Continued)

- Orthocladiinae
  - *Acricotopus* sp.
  - *Chaetocladius* sp.
  - *Corynoneura* sp.
  - *Cricotopus* sp.
  - *Cricotopus cricotopus*
  - *Cricotopus isocladius*
  - *Eukiefferiella* sp.
  - *Krenosmittia* sp.
  - *Orthocladius* sp.
  - *Paracladius* sp.
  - *Parakiefferiella* sp.
  - *Paraphaenocladius* sp.
  - *Parametriocnemus* sp.
  - *Pseudosmittia* sp.
  - *Thienemanniella* sp.
  - *Orthocladiinae* sp. 2
  - *Orthocladiinae* sp. 3
- Chironominae
  - *Chironomini* sp.
  - *Chironomus* sp. group 2
  - *Microtendipes* sp.
  - *Parachironomus* sp.
  - *Phaenopsectra phaenopsectra*
  - *Polypedilum* sp.
  - *Polypedilum tripodura* group
  - *Stictochironomus* sp.
  - *Tanytarsini* sp.
  - *Tanytarsus* sp.
  - *Cladotanytarsus* sp.
  - *Micropsectra* sp.
  - *Paratanytarsus* sp.
  - *Rheotanytarsus* sp.
  - *Zavrelia* sp.

- Simuliidae
  - Unidentified
  - *Simulium* sp.
- Stratiomyidae
  - Unidentified
  - *Euparyphus* sp.
- Tabanidae
  - *Tabanus* sp.
- Rhadionidae
  - *Atherix variegata*
- Emphididae
  - Unidentified
  - *Clinocera* sp.
- Anthomyiidae
  - *Limnophora aequifrons*
  - *Limnophora discreta*
- Muscidae
  - Unidentified

2.4.6.2 Methods

With the exception of analysis for arsenic which consists of a digestion procedure (EPA, 1973) followed by colorimetric analysis according to APHA (1971), no change in methods has occurred since Progress Report 3. See section 2.4.5.2 and 2.4.6.2 of Summary Progress Reports 2 and 3, respectively, for specific methods used for sediment chemistry studies.

2.4.6.3 Results

In the July - August collections, concentrations of the herbicides Tordon 22k and Silvex were always less than 0.02 μg/g in the sediments. Table 2.4-5 presents the results of sediment herbicide for July - August and August - September 1975. A summary of results of analysis for selected parameters for the White River and Yellow Creek is presented below. With the exception of aluminum, concentrations of the selected parameters were similar in the two streams during both sampling periods.

July - August	White River	Yellow Creek
Aluminum (μg/g)	3300-7800	5600-18300
Arsenic (μg/g)	1- 6	2- 9
Lead (μg/g)	4- 9	7- 16
Zinc (μg/g)	30- 65	19- 64

August - September	White River	Yellow Creek
Aluminum (μg/g)	3100-10600	7200-15000
Arsenic (μg/g)	2- 6	2- 9
Lead (μg/g)	5- 11	6- 13
Zinc (μg/g)	22- 49	25- 54

2.4.7 Macrophytes

2.4.7.1 Objectives

No change in objectives has occurred since Progress Report 3 - Summary. See section 2.4.7.1 of that report for specific objectives.

2.4.7.2 Methods

No change in methods has occurred since Progress Report 2 - Summary. See section 2.4.7.2 of that report for specific methods.

2.4.7.3 Results

Macrophytes were recorded at four stations during the July - August sampling, including Stations 2, 3, 5, and 14. Three patches of American speedwell, (*Veronica americana*) each 0.2 x 0.4 m, and scattered patches of shore crowfoot (*Ranunculus cymbolaria*) were observed at Station 2.

American speedwell was also in scattered patches at Station 3. At Station 5, one patch (0.3 x 1.0 m) of shore crowfoot and scattered plants of water crowfoot (*Ranunculus natans*) were found growing in the marsh area. Also at Station 5, an area of horned pondweed (*Zannichellia palustris*) 0.4 x 1.0 meters covered the bottom of the stream. Approximately 7 m downstream from the transect at Station 5, an extensive growth of water cress (*Rorippa nasturtium - aquaticum*) covered the stream bottom. At Station 14, a 10 x 15 m mat of horned pondweed was observed.

In August - September 1975 sampling, macrophytes were found at Station 1, 2, 3, 4, 5, 7, 9, 14, 19, 20, 21. At Station 1, 2, and 4, American speedwell was present. Scattered plants of this species were also found at Station 5, along with water cress. Providing a heavy cover at Station 5 was shore crowfoot. Scattered specimens of shore crowfoot were found at Station 3, 7, 9, and 19. At Station 19 this species occurred with scattered individuals of three-square (*Scirpus americanus*) and horned pondweed. Stonewort (*Chara wieneri*) formed an extensive mat on the pond bottom. Horned pondweed formed a 10 x 15 meter patch at Station 14 and provided heavy cover at Stations 20 and 21. Both three-square and Bayonet-grass (*Scirpus paludosus*) provided moderate cover at Stations 20 and 21.

2.4.8 Fish

2.4.8.1 Objectives

The objectives of fish studies remain the same as those stated in section 2.4.0 of Progress Report 2 - Summary.

2.4.8.2 Methods

No change in methods has occurred since Progress Report 2 - Summary. See section 2.4.8.2 of that report for specific methods employed in fish studies.

2.4.8.3 Results

During the July - August sampling, 201 fish representing ten species were captured in the White River. No fish were captured in Yellow Creek. The most abundant fishes captured were flannelmouth suckers and speckled dace. Table 2.4.5 presents the fish data from July - August.

Table 2.4.5 also presents the fish data from August - September. A total of 949 individual fish was captured in Yellow Creek and the White River. These included 12 species and two individuals of a flannelmouth bluehead sucker hybrid. Dominant taxa include speckled dace, flannelmouth sucker, fathead minnows and sculpins. The large number of fish collected reflects in part the high numbers of young-of-year fish occurring in quiet, shallow areas near the shore.

2.4.9. Springs and Seepages

2.4.9.1 Objectives

No change in objectives has occurred since Progress Report 3 - Summary. See section 2.4.9 of that report for specific objectives.

2.4.9.2 Methods

No change in methods has occurred since Progress Report 3 - Summary. See section 2.4.9 of that report for specific methods.

2.4.9.3 Results

Approximate locations of springs and seepages on or near Tract C-a are shown on Figure 2.4-2.

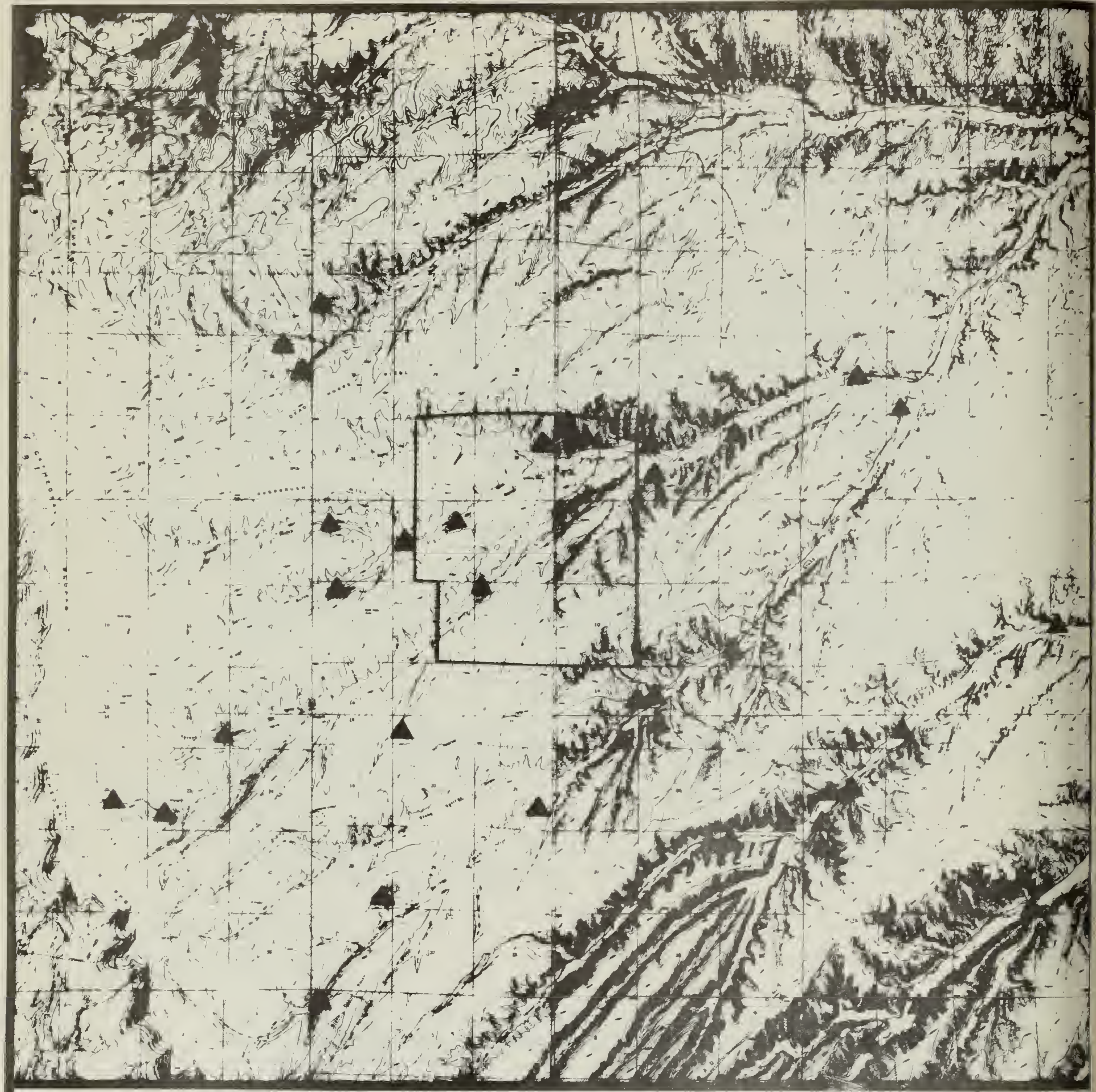
2.4.10 Hydrology

2.4.10.1 Objectives

The objective of this segment of the aquatic program is to measure the approximate stream velocities at each site at the time of sample collection to assist in characterizing the existing aquatic habitat.

Table 2.4.5. List of fish species and numbers captured in the White River during RBOSP Aquatic Baseline Studies, July - August and August - September 1975.

Common Name	Scientific Name	Number Captured	
		July - Aug.	Aug. Sept.
Brown trout	*Salmo trutta*		1
Mountain whitefish	*Prosopium williamsoni*		8
Roundtail chub	*Gila robusta*	5	5
Speckled dace	*Rhinichthys osculus*	32	408
Fathead minnow	*Pimephales promelas*		155
Red shiner	*Notropis lutrensis*	1	10
Carp	*Cyprinus carpio*	2	24
Flannelmouth sucker	*Catostomus latipinnis*	109	162
Bluehead sucker	*Catostomus discobolus*	15	66
Mountain sucker	*Catostomus platyrhynchus*		2
Channel catfish	*Ictalurus punctatus*		1
Black bullhead	*Ictalurus melas*	1	
Mottled sculpin	*Cottus bairdi*	10	1[illegible]
Flannelmouth X Bluehead	*Catostomus latipinnis* X *C. discobolus*		2



ENVIRONMENTAL STUDIES FOR THE RIO BLANCO OIL SHALE PROJECT

TRACT C-a

LIMNETICS, INC.
Denver, Colorado

12/75

SPRING & SEEPAGE LOCATIONS

▲ springs and seepages as of 12/75

2.4.10.2 Methods

Stream velocity is measured at each sampling site with Gurley flowmeters or an equivalent device.

2.4.10.3 Results

The approximate stream velocities during the July - August and August - September period are presented in Table 2.4-6.

2.4.11 Miscellaneous Studies

2.4.11.1 Objectives

No change in objectives has occurred since Progress Report 3 - Summary. See section 2.4.11 of that report for specific objectives.

2.4.11.2 Methods

No change in methods has occurred since Progress Report 3 - Summary. See section 2.4.11 of that report for parameters included in these studies.

2.4.11.3 Results

Data from the August - September 1975 sampling period are included in Table 2.4-7.

Table 2.4-6. Stream Flow, RBOSP Aquatic Baseline Studies, July - August and August - September 1975. (Results are expressed in feet per second and, where appropriate are given for bank side and point of maximum flow.)

Station	Flow (ft/sec) s m	Station	Flow (ft/sec) s m
July - August[1]		August - Sept.[2]	
1	0.4	1	<0.1
2	1.3	2	0.9
3	1.3	3	1.3
4	1.5	4	2.0
5	0.4	5	0.9
7	1.5	7	2.0
8	2.0	8	1.3
9	2.1	9	1.9
13	2.0	12	1.3
14	0.0	13	1.1
15	0.8	14	1.0
17	0.4	17	0.0
18	0.8	19	1.2
19	1.8	20	0.7
20	1.4	21	1.2
21	0.8	22	1.5
22	0.7	23	1.0;1.9
23	1.0;2.9	24	0.9;1.5
24	2.4;2.2	25	2.6;3.3
25	2.8;2.9	26	2.7;2.3
26	1.9;2.9	27	0.1;0.9
27	0.4;1.2	28	0.2;1.2
28	1.0;1.3	29	2.3;2.5
29	2.1;3.1	30	1.2;2.5
30	2.7;3.1	31	2.8;2.3
31	2.4;3.1	32	2.7;2.3
32	1.7;2.9	33	0.5;0.5
33	1.0;1.8	34	1.4;3.6
34	1.0;1.7	35	1.7;5.2
35	1.7;2.9		

---

[1] Stations 6, 10 - 12 and 16 were dry at the time of sampling.

[2] Stations 6, 10 - 11, 15 - 16 and 18 were dry at the time of sampling.

s = Stream side

m = Maximum flow point

Table 2.4-7. Water quality data. RBOSP Aquatic Baseline Studies, August - September 1975. (Data are expressed in mg/l unless otherwise noted.)

PARAMETER	STATION REPLICATE			
	25		34	
	A	B	A	B
Arsenic (As), Diss	< 0.01	< 0.01	< 0.01	< 0.01
Barium (Ba), Diss	< 0.02	< 0.10	< 0.01	< 0.01
Boron (Bo), Diss	< 0.50	< 0.50	< 0.50	< 0.50
Cadmium (Cd), Diss	< 0.01	< 0.01	< 0.01	< 0.01
Carbon (C) Organic	< 1	1	< 1	< 1
Carbon (C) Organic Diss	< 2	1	< 1	< 1
Carbon (C) Organic Suspended	< 1	< 1	< 1	< 1
Chemical Oxygen Demand (O_2)	10	10	9	10
Chromium (Cr) Total Diss	< 0.03	< 0.03	< 0.03	< 0.03
Copper (Cu), Diss	< 0.02	< 0.02	< 0.02	< 0.02
Cyanide (Cn), Total	< 0.001	< 0.001	< 0.001	< 0.001
Fluoride (F), Diss	0.40	0.40	0.44	0.44
Iron (Fe), Total Diss	0.04	0.03	< 0.02	< 0.02
Lead (Pb), Diss	< 0.05	< 0.05	< 0.05	< 0.05
Lithium (Li) Diss	< 0.02	< 0.02	< 0.02	< 0.02
Manganise (Mn), Diss	< 0.02	< 0.02	< 0.02	< 0.02
Mercury (Hg), Diss (µg/l)	0.3	0.02	< 0.02	< 0.2
Nitrogen (N), Organic	0.27	0.34	0.34	0.18
Phosphorus (P), Total Diss	0.01	0.02	0.02	0.03
Phenolic compounds (Phenol)	0.006	0.005	0.006	
Selenium (Se), Diss	< 0.01	< 0.01	< 0.01	< 0.01
Solvent extract (Oil)	< 0.003	< 0.003	< 0.003	< 0.003
Sulfate (S), Diss	50	52	52	58
Sulfide (S), Diss	< 0.02	< 0.02	< 0.02	< 0.02
Sulfur (S), Organic	3	7	4	5
Zinc (Zn), Diss	< 0.02	< 0.02	< 0.02	< 0.02

Diss = Dissolved

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2.5 Other Environmental Programs

2.5.1 Soils Survey and Productivity Assessment Studies

An inventory of types, physical and chemical characteristics, and distribution of the soils found on Tract C-a and adjacent areas is required for ecological analysis and engineering studies. A basic requirement for understanding the ecology of any natural area is soils data. Soils information is needed for designing a revegetation program and ecological analysis to provide understanding of the diverse relationships involved between soils, plants, and wildlife. Information on soils is necessary to adequately plan road construction, water impoundment and diversion structures, and locations and design of various structures. Data from overburden analyses will be used to anticipate possible toxic strata which may cause difficulties in the revegetation program or lead to potential pollution of aquatic systems through leaching action on stockpiles or spent shale disposal sites.

Evaluation of chemical and physical properties of each soil series identified on Tract C-a and adjacent areas is needed for analyzing vegetation-soil relationship; defining suitability of soil as a growth medium for revegetation; and identifying erosion potential, locally toxic soils (or potentially toxic heavy metals), and the quantity of soil available for covering the overburden-processed shale complex prior to revegetation.

A discussion of the soil series found in the area is presented in this report. A description of the methods used in chemical and physical analysis and overburden studies and data available to date will be presented in the DDP.

2.5.1.1 Objectives

The objectives of the soil survey were described in Progress Report 4 - Summary Section 2.5.1.1.

2.5.1.2 Methods

Methods employed in the soils survey were discussed in Section 2.5.1.2 of Progress Report 2 - Summary. Refer to that report for additional information on methods.

2.5.1.3 Results

A description of the 11 soil types and one rock outcrop was presented in Section 2.5.1.3 of Progress Report 4 - Summary.

Soils found in the vicinity include:

- Aridic Haploboroll
- Forelle
- Glendive
- Hagga
- Hanly
- Havre
- Lithic Haploboroll
- Piceance
- Redcreek
- Rentsac
- Yamac

A Rock outcrop-Torriorthents association is also found in the area.

Aridic Haploboroll soils are moderately deep, well-drained soils found on foothill sideslopes. They are commonly associated with vegetation suitable to summer livestock grazing and mule deer winter habitat.

Forelle soils are deep, well-drained soils which commonly support dryland farming and wildlife habitat on uplands and terrace slopes.

Glendive soils are of alluvial origin and are deep and well-drained. They will support good pastures when irrigated, which provide livestock grazing and wildlife habitat. They are found in valley bottoms.

Hagga soils are deep, poorly-drained soils found on valley bottoms. Native and planted grasses occur in association with these soils.

Hanly soils are deep and excessively well-drained. They occur as alluvial fans and in narrow valleys. Grasses, forbs and brush occur in association with these soils and provide habitat suitable for wildlife, especially rabbits and deer.

Havre soils, which occur on floodplains, are deep and well-drained. They provide a suitable substrate for grasses and are sometimes irrigated to provide pasture for livestock grazing.

Lithic Haploboroll soils are shallow, well-drained soils found on upland slopes and ridgetops. They support vegetation suitable for summer livestock grazing and mule deer winter browzing.

Piceance soils are moderately deep and well-drained. They are found on upland slopes and ridges in association with vegetation suitable for livestock grazing and wildlife habitat.

Redcreek soils are shallow and well-drained and occur on mountain sideslopes. They support a sparse vegetation cover suitable for limited livestock grazing and wildlife habitat.

Rentsac soils are shallow and well-drained and are found on upland entrenched terraces. They produce vegetation suitable for livestock grazing.

Yamac soils are deep and well-drained. They occur on rolling uplands and ridges and support vegetation suitable for livestock grazing and wildlife habitat.

Rock outcrop-Torriorthents occur on extremely steep terrace breaks in drainageways of the area. They support scattered pinyons, junipers and shrubs.

2.5.2 Archaeological Survey

2.5.2.1 Objectives

The basic objectives of the archaeological studies remain unchanged from those described in Section 2.5.2.1, Progress Report 4 - Summary.

2.5.2.2 Methods

Field methods were described in Progress Report 4 - Summary, Section 2.5.2.2. Artifacts collected during the field surveys were subjected to additional analysis during the quarter. Initial laboratory analysis involved the separation of diagnostic material from non-diagnostic material. Each diagnostic artifact was then measured and described in terms of shape, method of manufacture (e.g., flaking) and material used. Location, topography, and areal extent of the site was also recorded. This information was studied to determine cultural affiliations and approximate length and extent of utilization. To further develop the archaeological description of the area, comparisons of these artifacts were made to descriptions of artifacts previously dated and identified from adjacent areas.

2.5.2.3 Results

On the basis of information derived from analysis of artifacts collected from 196 locations in the study area, three site classifications were defined. These site classifications indicate "importance for excavation" in the following order:

• Primary Sites:	First priority for excavation in areas where disturbance will occur. Likely to yield additional material on excavation.
• Secondary Sites:	Second order priority for excavation in areas to be disturbed. Could possibly yield additional information upon excavation.
• Tertiary Sites:	Last in importance. Not recommended for excavation. Unlikely to yield additional material if excavated.

The first recommendation for archaeological preservation is to avoid the area whenever possible. However, in the event that disturbance cannot be avoided, excavations will be recommended on the basis of site classifications as indicated above.

The determinations of site classification were based on number and variety of tools (or other artifacts) at the site, the presence of wastage associated with tool making, the presence of structures, and/or areal extent of the site.

Primary sites had moderately large numbers of tools and/or moderate amounts of wastage. Two sites containing tipi-like structures (wickiups) were also defined as primary sites because of the diagnostic importance of such structures. Evidence found at primary sites indicates that they may either have been occupied by a fairly large group of people on a single occasion or reoccupied by a small group over a period of years. The nature of use makes discovery of additional material such as buried pithouses, firepits or storage structures likely through excavation. Fourteen primary sites were found during the survey (Table 2.5.2-1). None was found on tract, but the 10 found on 84 Mesa and the one within a 1-mile perimeter of the tract are shown in Figure 2.5.2-1.

Table 2.5.2-1 Number, location and classification of archaeological sites found during survey of Tract C-a, RBOSP

	Location			
Classification	Tract C-a	84 Mesa	1-mile Perimeter	Off Tract*
Primary	0	10	1	3
Secondary	0	10	5	32
Tertiary	22	40	31	42
Totals	22	60	37	77

* Areas off tract other than 84 Mesa and the 1-mile perimeter.

Secondary sites yielded less material and covered a smaller area than primary sites. They probably represent short periods of occupation (i.e., a single camping period). They possibly harbor buried materials which could be uncovered by excavation. A total of 47 secondary sites (Table 2.5.2-1) was described for the survey area. Most of these (32) were found in the expanded off-tract survey area. 84 Mesa and 1-mile perimeter sites are shown on Figure 2.5.2-1.

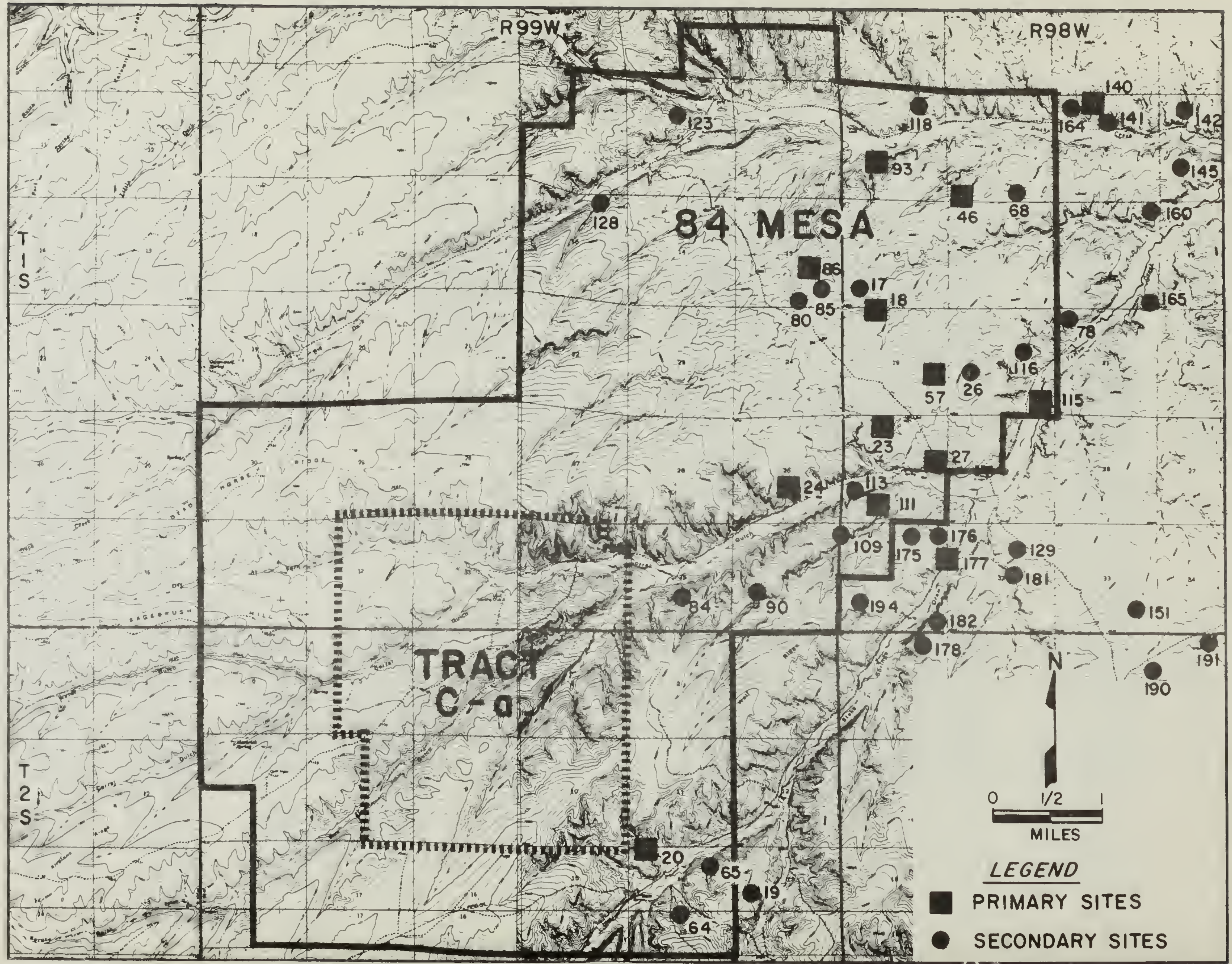


Figure 2.5.2-1 Locations of primary and secondary archaeological sites on Tract C-a, 1-mile perimeter, and 84 Mesa.

Tertiary sites yielded the smallest amount of artifactual material. This material was usually limited to a few chips of toolstone or one or two artifacts within a small area. Most of the locations discovered (135) fall into this classification (Table 2.5.2-1). The scarcity of artifacts indicates that the area was not used as a camp site; therefore, excavation would probably not provide additional material.

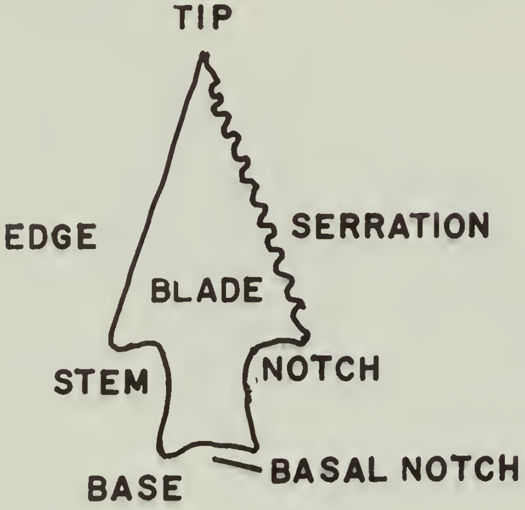
All of the sites located during the survey were located in the open with little or no natural protection other than plant cover and variations in topography. In addition, all but two sites produced only lithic (stone) material. The limited nature of artifacts is closely related to the use of open sites for encampments. Tools fashioned from plant or animal material are not readily preserved in open sites where decay, oxidation, insects and other factors quickly destroy such materials. Organic artifacts are usually found only in caves, overhangs or other protected areas where they may be preserved by burial or protected from exposure to the elements.

Further analysis of artifactual material revealed that in addition to the three basic tool types originally described (flaked stone tools, ground stone implements, and pottery) several variations of these had been used. The differences were related to type of material used, method of manufacture, and overall shape.

Flaked stone tools (projectile points, blades, and knives) were made from rock rich in silica including jasper, chalcedony, petrified wood, agate, obsidian or quartzite. These materials are fine-grained and suitable for controlled flaking.

The two most often used methods for making flaked stone tools were percussion flaking and pressure flaking. Percussion flaking is accomplished by striking two stones together or by striking the toolstone with an antler or piece of hard wood. Moderate-sized flakes are thereby broken off to produce a "roughed out" point. Pressure flaking is the means by which roughed out points are finished to a fine cutting edge. The edge of the tool is gently pressed using an antler tine or similar device until very small flakes are dislodged. The process is repeated until the cutting edge is ready for use.

One important type of flaked stone tool found in the survey area was the projectile point. The basic design of a projectile point is shown below:



Basic design variations of projectile points from the study area included unnotched points; basal, side, or corner notched points; and straight, convex, or concave stemmed points. Various types of projectile points from the study area, along with their cultural affiliations, are illustrated in Figures 2.5.2-2 through 2.5.2-4.

Another important tool in this category is the blade. Blades are chipped on both sides to provide a cutting edge. They were used primarily for processing game. Several blades found during the survey are illustrated in Figure 2.5.2-5.

Scrapers were flaked on one side to provide an angular cutting edge which could be used to prepare hides or make other tools. Most scrapers found in the study area were very small (Figure 2.5.2-6) and were probably held in the fingers.

In addition to the tool types listed above, others found included drills, gravers, cores and choppers. All of these

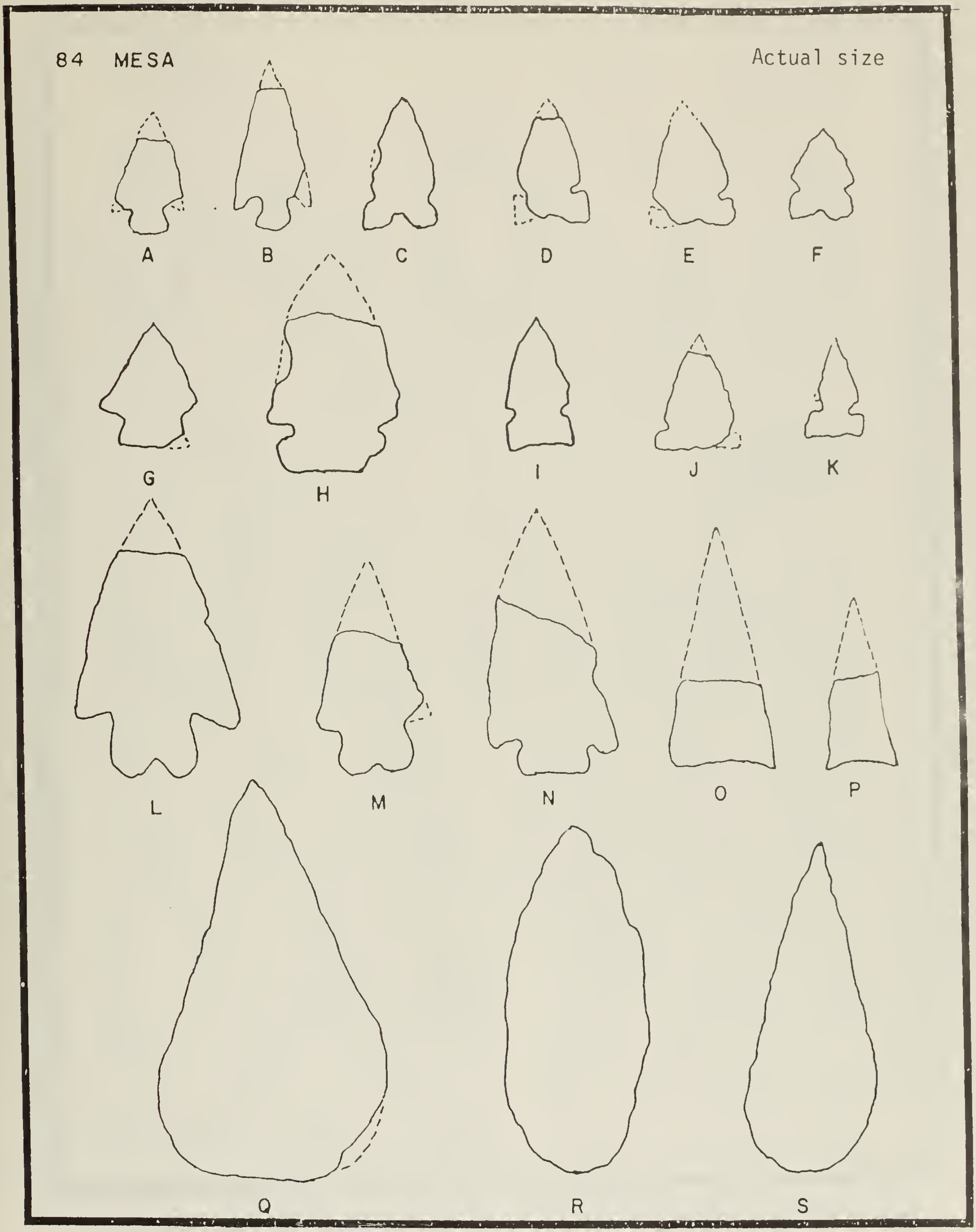


Figure 2.5.2-2 Projectile points (top three rows) and blades (bottom row) found during RBOSP archaeological survey. Cultural affiliations: A-B, Fremont; C-K and N-S, Indeterminate; L-M, Archaic.

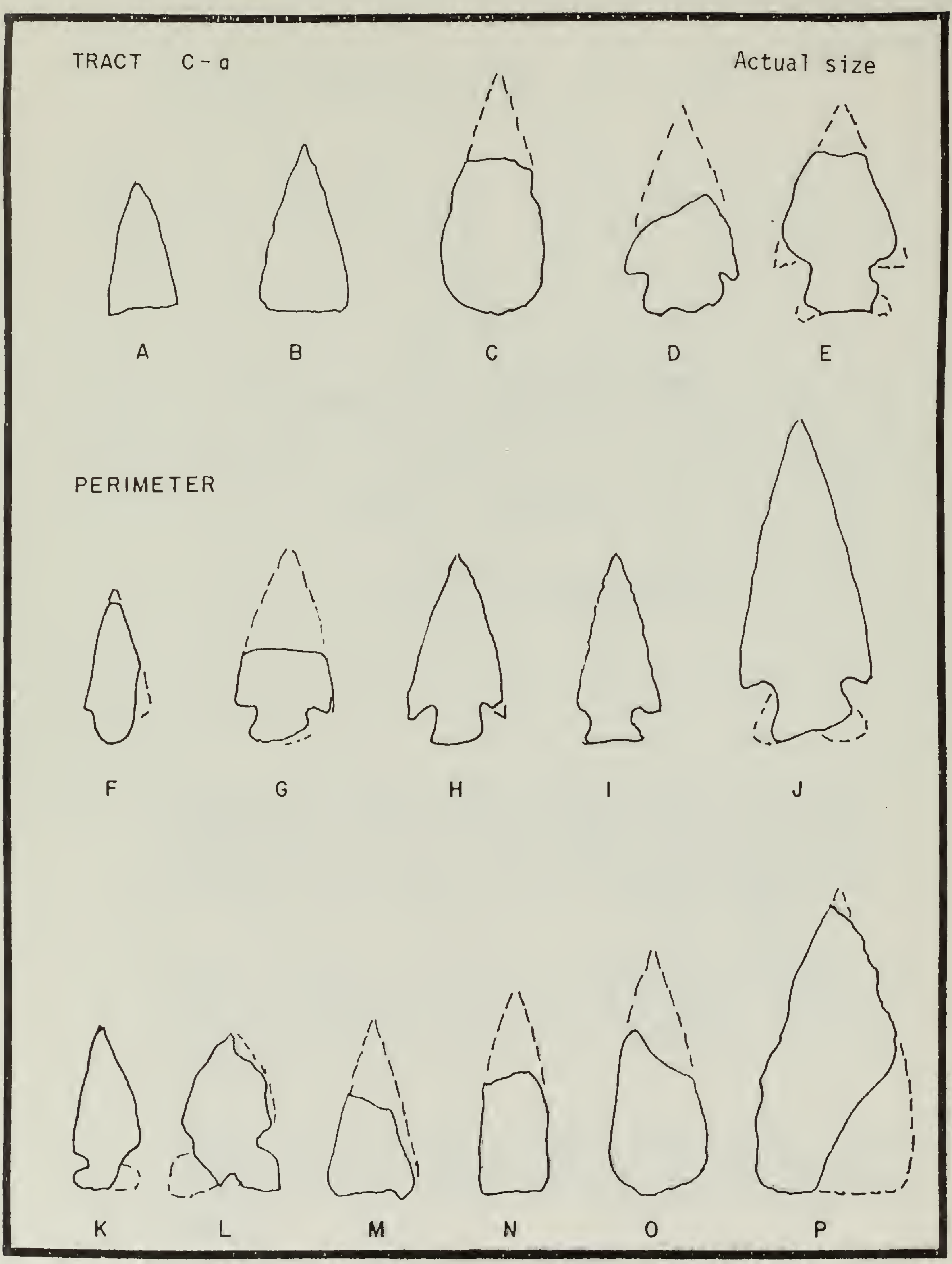


Figure 2.5.2-3 Projectile points found during RBOSP Archaeological survey. Cultural affiliations: A-F and J-P, indeterminate; G-I, Fremont.

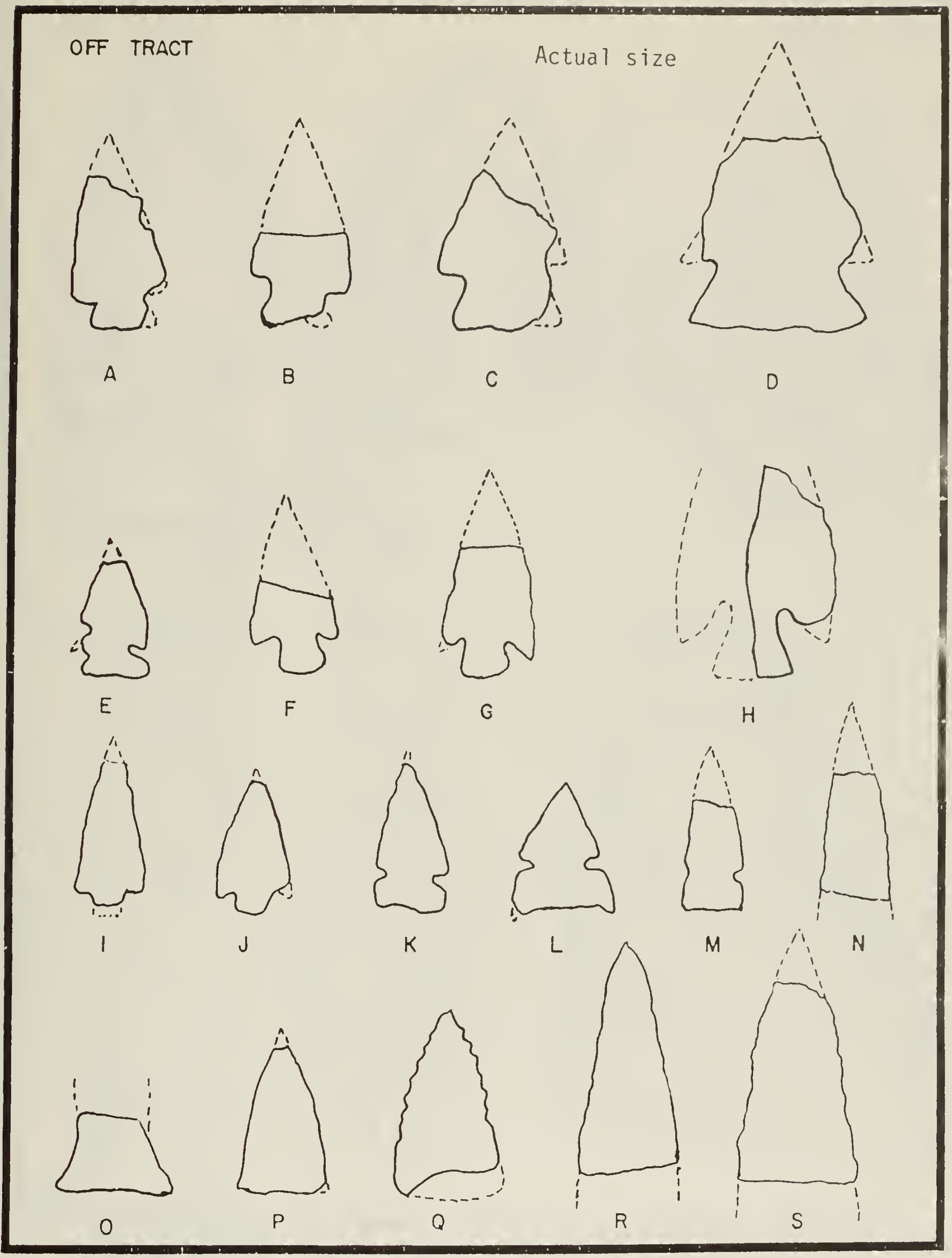


Figure 2.5.2-4 Projectile points found during RBOSP archaeological survey. Cultural affiliations: A-E and I-S indeterminate; F-G, Fremont.

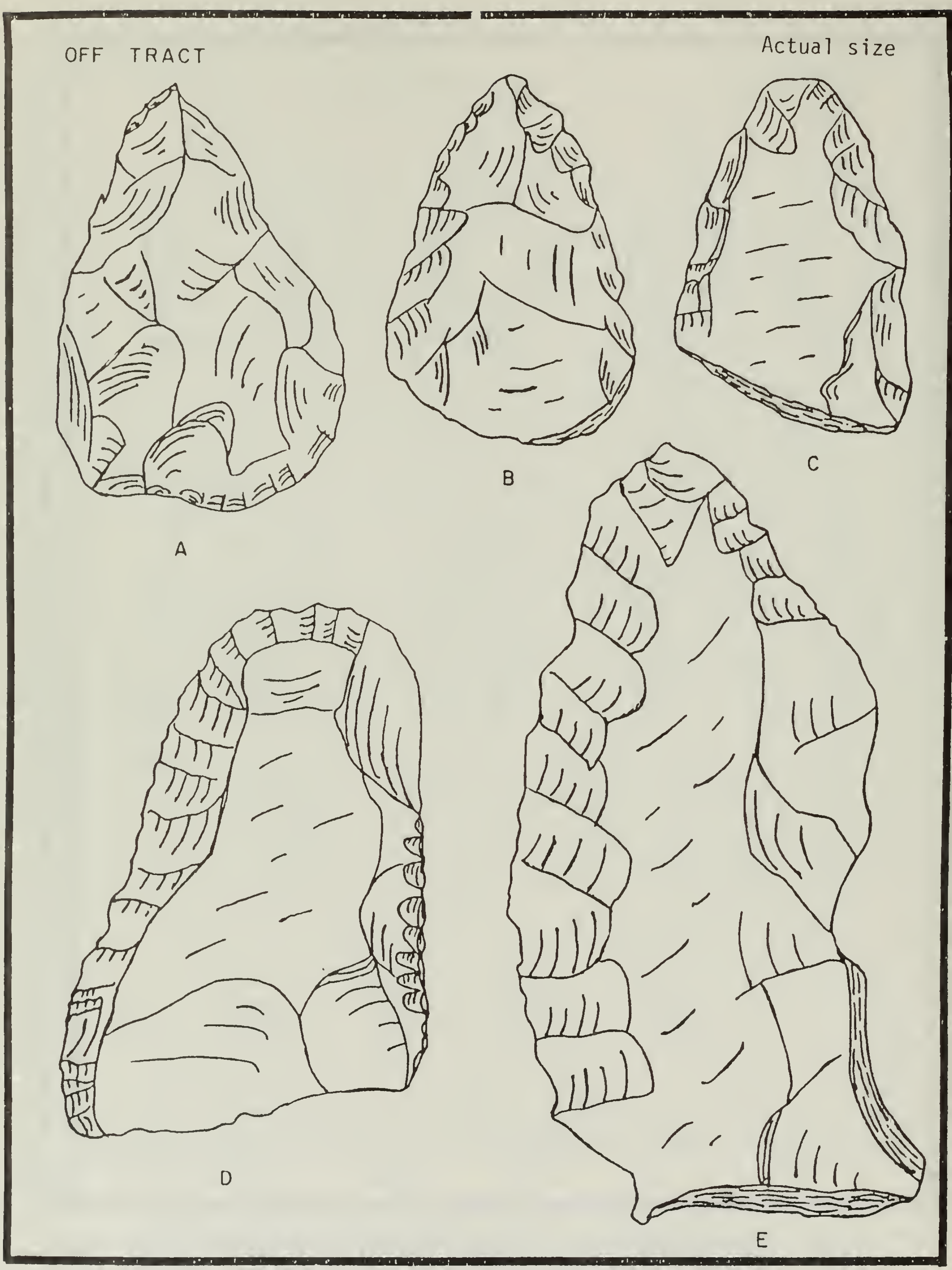


Figure 2.5.2-5 Blades found during RBOSP archaeology survey.

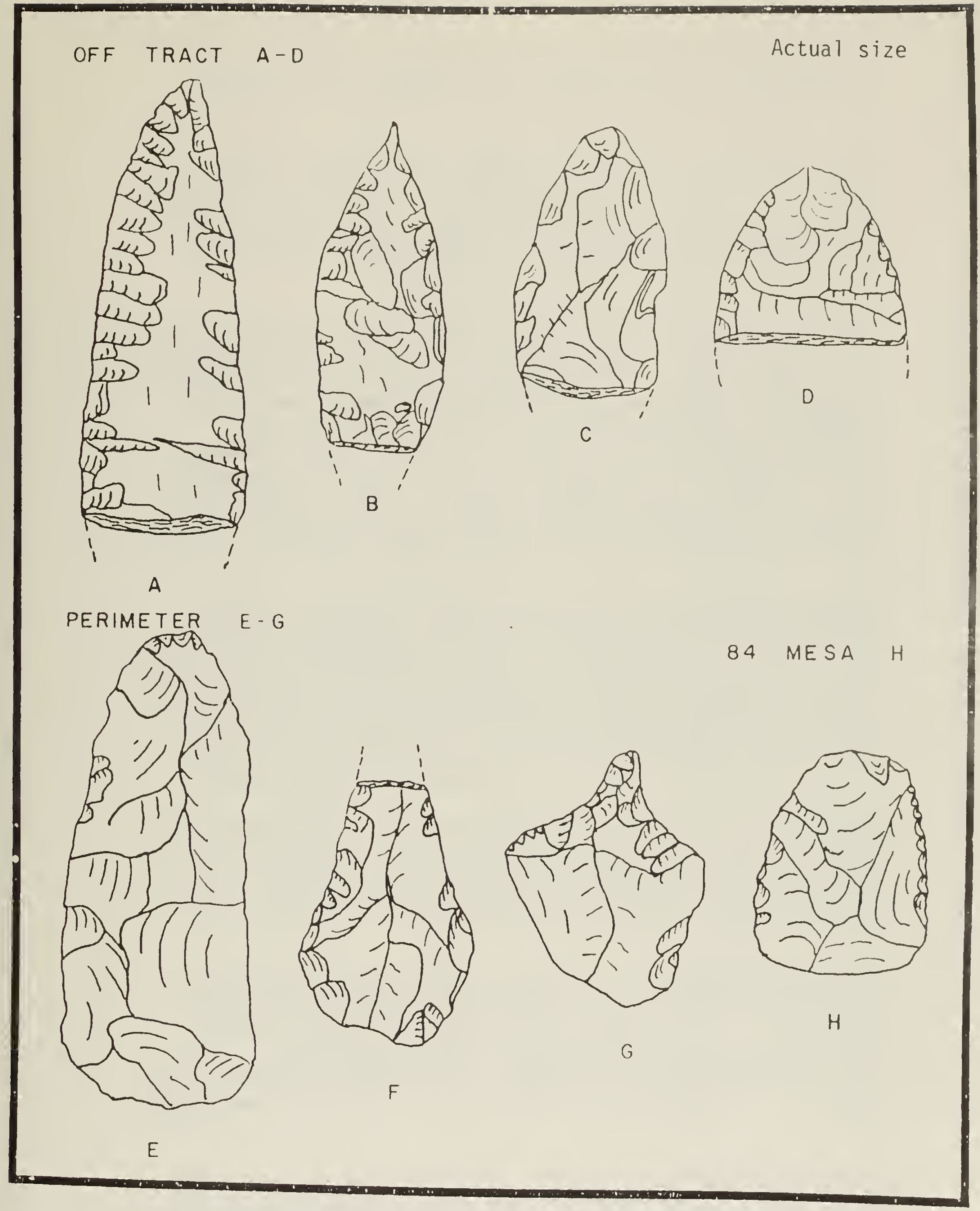


Figure 2.5.2-6 Scrapers found during RBOSP archaeological survey.

were produced by flaking, and areas where manufacture of these took place can often provide significant deposits of wastage for determining extent of use.

The fine-grained rocks which were used to make flaked tools found during the survey do not naturally occur in the area. The closest known source occurs in alluvial deposits in the White River Drainage. Other sources occur in Utah and southwestern Wyoming. The presence of these tools, therefore, indicates transport by man.

Ground stone tools were commonly made from stone found in the area. These tools were larger and were used for grinding or crushing food. The production of these tools appeared to be less formalized. The moveable element (mano) was frequently merely a stream cobble worn smooth by the tumbling action of the water. The lower element (metate) was an irregularly shaped flat rock in which a depression was eventually worn through long use. These were probably left at campsites and re-used with each occupation. Metates found during the survey are illustrated in Figure 2.5.2-7.

Only a few samples of the third major type of artifact (pottery) were found during the survey. These consisted only of small broken pieces, making identification difficult. Most of the pottery found was an undecorated gray ware, but two small pieces of black-on-white pottery, similar to that found in Utah and Dinosaur National Monument, were also recovered. The overall scarcity of pottery suggests that it was transported into the area rather than made there.

A complete list of the numbers and types of artifacts found in the survey area, locations where found, site classification, and cultural affiliations appears in Tables 2.5.2-2 through 2.5.2-4. Similar information for off-tract sites is presented in Table 2.5.2-5.

The total inventory of artifacts recovered from Tract C-a and adjacent areas is not impressive. The archaeological importance of the Piceance Basin, and the survey area in particular, stems from the fact that relatively no exploration has been done there. The impending development of the area emphasizes the importance of these archaeological finds.

Field and laboratory analyses indicate there were at least four periods of occupation of the area: an Archaic period which perhaps began in 7000 to 6000 B.C.; followed by the Fremont culture in 500 A.D.; the Ute, whose origin is unknown; and, finally, 19th century Anglos.

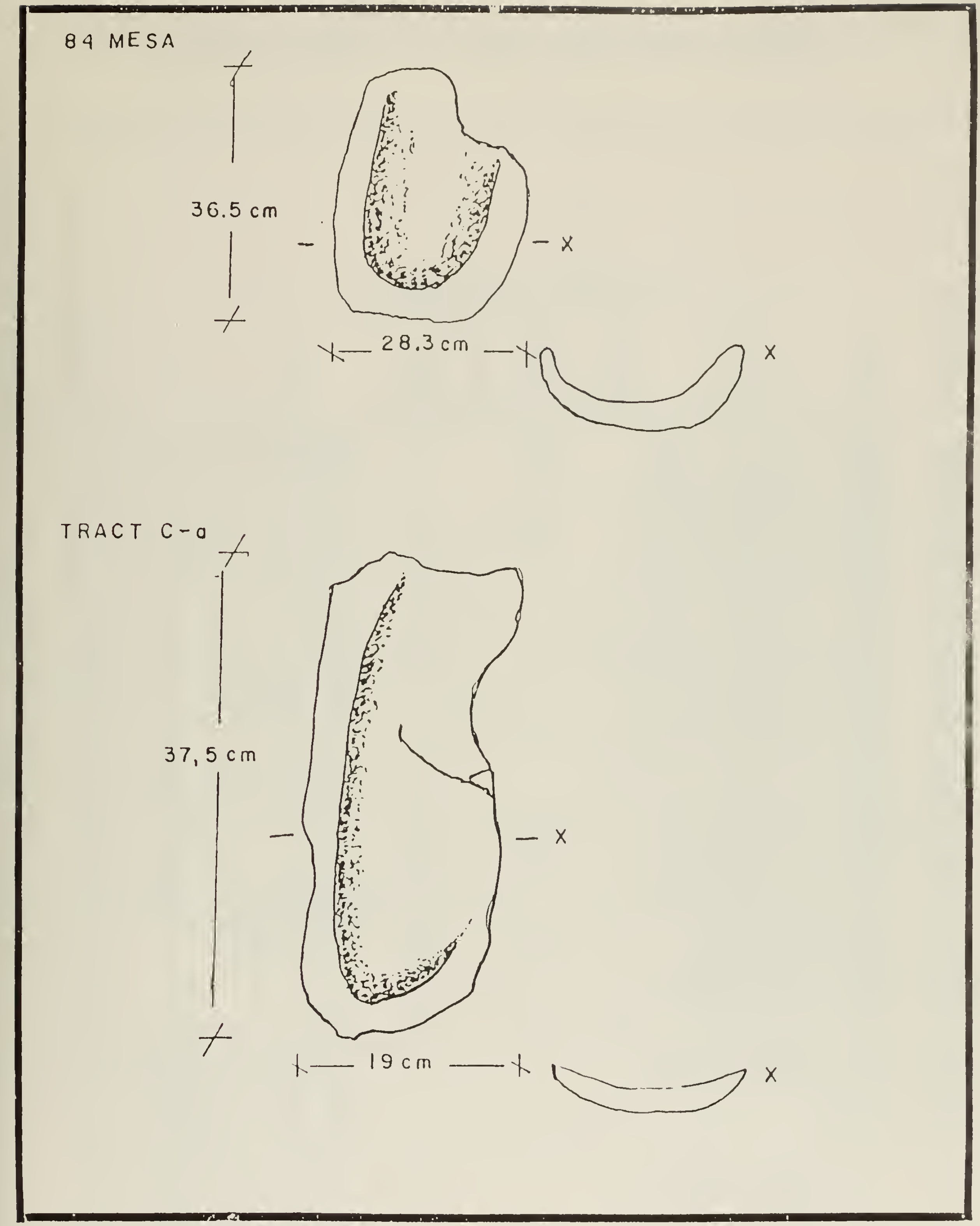


Figure 2.5.2-7 Metates found during RBOSP Archaeological survey, summer 1975.

Table 2.5.2-2 Field site number, site location and material culture analysis located June through September 1975 on Tract C-a, RBOSP.

Field Number	Township	Range	Section	Tool Type					Site Classification	Cultural Affiliation
				Point	Knife	Scraper	Flakes	Other		
4	T2S,	R99W	S3 , SE¼ NW¼		1f		3	Metate	T	-
5	T1S,	R99W	S34, SE¼ NE¼		1f				T	-
6	T1S,	R99W	S33, NE¼ SW¼	1f	1f				T	-
7	T2S,	R99W	S4 , NW¼ NE¼		1f	6	9		T	-
8	T1S,	R99W	S34, NW¼ SW¼				3		T	-
9	T1S,	R99W	S33, NW¼ SW¼				3		T	-
14	T2S,	R99W	S4 , NE¼ SW¼			1			T	-
15	T1S,	R99W	S34, SE¼ SW¼	1f		1	6		T	-
16	T1S,	R99W	S34, SW¼ SW¼	1f		1	2		T	-
29	T2S,	R99W	S4 , NW¼ SW¼					Tool fragment	T	-
33	T1S,	R99W	S33, SE¼ SW¼			1f			T	-
34	T1S,	R99W	S33, SW¼ NE¼			1f			T	-
37	T2S,	R99W	S10, NW¼ SW¼	1f					T	-
38	T2S,	R99W	S9 , NW¼ NE¼				1		T	-
39	T2S,	R99W	S10, SW¼ SW¼				2		T	-
40	T2S,	R99W	S10, NW¼ NE¼				1		T	-
41	T2S,	R99W	S3 , SE¼ SE¼	1	3f		8		T	-
42	T2S,	R99W	S3 , SW¼ SE¼					Metate F	T	-
43	T2S,	R99W	S9 , NE¼ NW¼				1	Mano fragment		
							1	Tool fragment	T	-
45	T1S,	R99W	S33, NE¼ SE¼	3f	1f		30		T	-
51	T2S,	R99W	S10, SE¼ SE¼			1f			T	-
54	T2S,	R99W	S5 , SW¼ SW¼				5		T	-

f = Identifiable fragmentary tool

T = Tertiary sites

Table 2.5.2-3 Field site number, site location and material culture analysis for archaeological sites located June through September 1975 in the 1-mile perimeter of Tract C-a, RBOSP.

Field Number	Township	Range	Section	Tool Type					Site Classification	Cultural Affiliation
				Point	Knife	Scraper	Flakes	Other		
10	T1S,	R99W	S29, NW¼ SW¼			1f			T	-
11	T1S,	R99W	S29, SW¼ SW¼	1f			2		T	-
12	T1S,	R99W	S29, SW¼ SE¼				4	Graver	T	-
13	T1S,	R99W	S29, SE¼ SE¼		1f	1	1		T	-
20	T2S,	R99W	S14, NW¼ NW¼	2-4f	2f	3-4f	94	Hammerstone, drill(f)	P	F(?)
21	T2S,	R99W	S15, SW¼ NE¼		1		13		T	-
25	T1S,	R99W	S27, SW¼ SE¼			2	7		T	-
28	T2S,	R99W	S8 , SW¼ SW¼				1		T	-
30	T2S,	R99W	S17, SE¼ SE¼	1f		2	19		T	-
32	T1S,	R99W	S27, NE¼ SW¼			1f	15	1 Tooth fragment	T	-
35	T2S,	R99W	S11, SW¼ NE¼				2		T	-
36	T2S,	R99W	S11, NE¼ SE¼	1f	1	3f	20		T	-
44	T2S,	R99W	S17, SW¼ NW¼	1			1		T	-
47	T1S,	R99W	S35, NE¼ NW¼		1f		22		T	-
50	T2S,	R99W	S16, NE¼ NE¼				2		T	-
52	T2S,	R99W	S15, SW¼ NE¼		1 Historic		5		T	-
53	T2S,	R99W	S6 , SW¼ NE¼		1			1 Toolstone	T	-
55	T2S,	R99W	S15, SE¼ NE¼	2f	1f		4	Toolstone	T	-
56	T2S,	R99W	S6 , SW¼ SE¼				1		T	-
64	T2S,	R99W	S14, NW¼ SE¼	2f	2f	1		Mano, fossil bones, core	S	F(?)
65	T2S,	R99W	S14, NE¼ NE¼	1				Hammerstone		
				3f	1	1f	107	Mano fragment	S	F(?)
66	T2S,	R99W	S14, NE¼ NW¼	1f		3f	25		T	-
67	T2S,	R99W	S11, SW¼ SE¼			1f	10	Hammerstone	T	-
70	T2S,	R99W	S11, SE¼ NE¼				1		T	-
71	T2S,	R99W	S11, NW¼ NW¼			1f	8		T	-
72	T2S,	R99W	S2 , NE¼ SW¼				1		T	-
81	T2S,	R99W	S2 , NE¼ NE¼	1					T	-
				2f			2	Core	T	-
82	T1S,	R99W	S35, SW¼ SW¼				2	Mano fragment	T	-
83	T1S,	R99W	S35, SW¼ SW¼					Mano	T	-
84	T1S,	R99W	S35, NW¼ SE¼	2f	1	2f	22	1 Mano fragments, core	S	I

Table 2.5.2-3 (Continued)

				Tool Type						
Field Number	Township	Range	Section	Point	Knife	Scraper	Flakes	Other	Site Classification	Cultural Affiliation
94	T1S,	R99W	S29, NW¼ SW¼	1f	1f	3	14		T	-
95	T1S,	R99W	S28, SW¼ NE¼	1f			2		T	-
97	T1S,	R99W	S30, NE¼ NW¼					Toolstone	T	-
103	T1S,	R99W	S30, SE¼ SE¼				3		T	-
104	T1S,	R99W	S31, SW¼ NW¼					Toolstone	T	-
109	T1S,	R99W	S36, NE¼ NE¼	1	1	2	82	Mano	S	F(?)
113	T1S,	R98W	S30, SW¼ SW¼	1f	1	2	5	Mano (f)	S	I

f = Identifiable fragmentary tool

P = Primary site

S = Secondary site

T = Tertiary site

- = Cultural affiliation not attempted because of small number of artifacts

I = Indeterminate

F = Fremont

Table 2.5.2-4 Field site number, site location and material culture analysis for archaeological sites located June through September 1975 on 84 Mesa, RBOSP.

Field Number	Township	Range	Section	Tool Type					Site Classification	Cultural Affiliation
				Point	Knife	Scraper	Flakes	Other		
1	T1S,	R98W	S29, SE¼ NW¼		2f	1 1f	7		T	-
2	T1S,	R99W	S25, SE¼ NE¼	1	1f		3	Basin Metate (#2)	T	-
3	T1S,	R99W	S36, NW¼ SW¼	1f	1f		5		T	-
17	T1S,	R98W	S18, SE¼ SW¼	1f	3f	3f	6		S	I
18	T1S,	R98W	S18, SE¼ SW¼	1 2f	1f	1f	104	Chopper (f)	P	F(?)
22	T1S,	R98W	S18, SE¼ SW¼				9		T	-
23	T1S,	R98W	S30, NW¼ NE¼	3 7f	1 6f	15	178	Hammerstone, drill, 3 choppers	P	F
24	T1S,	R99W	S25, NW¼ SE¼	1f		4f	97	Mano fragments	P	F(?)
26	T1S,	R98W	S20, NW¼ SW¼	1	2f	2f	1		S	F(?)
27	T1S,	R98W	S30, SE¼ NE¼	1 11f	9	16	177	Potsherds, drill F cores, blades, Manos	P	A-F
31	T1S,	R98W	S30, SE¼ NW¼	2	1				T	-
46	T1S,	R98W	S8 , SW¼ SW¼	1f	1f		15	1 historic knife, hammerstone, 5 Mano fragments, chopper, core, trade beads, wickiup structure	P	U
48	T1S,	R98W	S19, SE¼ NW¼	1			2		T	-
49	T1S,	R98W	S19, NW¼ SE¼	1f			3		T	-
57	T1S,	R98W	S19, NE¼ SE¼	2f	3	5	63	Drill (f), pottery	P	F
58	T1S,	R98W	S20, SW¼ NW¼				3	1 potsherd	T	-
59	T1S,	R98W	S20, SE¼ NW¼					Mano fragment	T	-
60	T1S,	R98W	S19, NE¼ SE¼					Mano fragment	T	-
61	T1S,	R98W	S19, NE¼ SE¼					Mano	T	-
62	T1S,	R98W	S19, SE¼ SE¼			1f	2		T	-
63	T1S,	R98W	S20, NE¼ NW¼				2		T	-
68	T1S,	R98W	S8 , SW¼ SE¼		1	2f	9		S	I
69	T1S,	R98W	S17, NW¼ NE¼				1		T	-

Table 2.5.2-4 (Continued)

Field Number	Township	Range	Section	Tool Type Point	 Knife	 Scraper	 Flakes	 Other	Site Classification	Cultural Affiliation
73	T1S,	R98W	S18, NE¼ SE¼	1f			2	Mano	T	-
74	T1S,	R98W	S18, NE¼ SE¼	1f		3	7	2 Mano fragments, chopper	T	-
75	T1S,	R98W	S18, NE¼ SE¼				3		T	-
76	T1S,	R98W	S17, NW¼ SW¼			1f			T	-
77	T1S,	R98W	S18, SE¼ SE¼					Toolstone	T	-
80	T1S,	R99W	S13, SW¼ SE¼	1f	1f	4	25	Mano fragment, toolstone	S	I
85	T1S,	R99W	S13, SW¼ SE¼		3f	4f	99		S	I
86	T1S,	R99W	S13, NE¼ SE¼	1f	3f 4	1 2f	71	Toolstone, pottery	P	F
87	T1S,	R98W	S30, NW¼ NE¼	1f			36	Toolstone	T	-
88	T1S,	R98W	S30, NW¼ NW¼		1f	2		Mano	T	-
90	T1S,	R99W	S36, NE¼ SW¼	1	3f	1	22	Mano	S	I
91	T1S,	R99W	S11, SE¼ SW¼				1		T	-
92	T1S,	R98W	S8 , NW¼ SE¼			1	2		T	-
93	T1S,	R98W	S7 , SW¼ SW¼					Wickiup structure toolstone	P	U
105	T1S,	R99W	S14, SE¼ SE¼			1f	1		T	-
106	T1S,	R98W	S29, SW¼ NW¼			1f	1		T	-
107	T1S,	R99W	S36, SE¼ NW¼		1f	1f	14		T	-
108	T1S,	R99W	S14, SE¼ SE¼				4		T	-
110	T1S,	R99W	S25, NE¼ SE¼			1			T	-
111	T1S,	R98W	S30, SE¼ SW¼	2		6	103	Drill fragment, Mano fragments, toolstone	P	I
112	T1S,	R98W	S30, SW¼ SE¼				2		T	-
114	T1S,	R98W	S20, SE¼ SE¼				6		T	-
115	T1S,	R98W	S20, SE¼ SE¼	1f	1	6	135	Bone, Mano toolstone, pottery	P	F
116	T1S,	R98W	S20, SW¼ NE¼	2		1	13	Mano, toolstone	S	F(?)
117	T1S,	R98W	S29, NE¼ NW¼		2	2	9	Mano fragment	T	-
118	T1S,	R98W	S7 , NE¼ NE¼		4f	1f	25	1 Mano fragment	S	I
119	T1S,	R99W	S13, SW¼ NE¼	1f			11	Toolstone	T	-
120	T1S,	R99W	S11, SE¼ NE¼				2		T	-
121	T1S,	R99W	S2 , SW¼ SE¼					Mano fragment	T	-
122	T1S,	R99W	S12, NE¼ NW¼			1f	6		T	-

Table 2.5.2-4 (Continued)

				Tool Type						
Field Number	Township	Range	Section	Point	Knife	Scraper	Flakes	Other	Site Classification	Cultural Affiliation
123	T1S,	R99W	S11, SW¼ NE¼			4	17	Core, 2 Mano fragments, toolstone, bone	S	I
124	T1S,	R99W	S10, SE¼ SW¼	1			74		T	-
125	T1S,	R98W	S19, SW¼ SE¼			1	8		T	-
126	T1S,	R99W	S15, SE¼ NE¼				1		T	-
127	T1S,	R99W	S11, SW¼ SW¼			1	2		T	-
128	T1S,	R99W	S15, NW¼ NE¼			1 1f	13	1 Mano fragment, 1 hammerstone, toolstone	S	I
143	T1S,	R98W	S18, NW¼ SW¼			1f	1		T	-

f = Identifiable fragmentary tool

P = Primary

S = Secondary

T = Tertiary

- = Cultural affiliation not attempted because of small number of artifacts

I = Indeterminate

A = Archaic

F = Fremont

U = Historic Ute

Table 2.5.2-5 Field site number, site location and material culture analysis for archaeological sites located June through September 1975 on off-tract sites[1] and Yellow Creek drainage.[2]

				Tool Type					
Field Number	Township	Range	Section	Point	Knife	Scraper	Flakes	Other	Site Classification
19	T2S,	R99W	S13, SW¼ NW¼	2f	1 1f	1f	18	Hammerstone	S
78	T1S,	R98W	S21, NW¼ NW¼	1f		1f	5		S
79	T1S,	R98W	S16, SE¼ SW¼			1f			T
89	T2S,	R100W	S13, SE¼ NE¼		1f				T
96	T1S,	R98W	S9 , NE¼ SW¼					Mano fragment	T
98	T1S,	R98W	S5 , SE¼ SE¼				1	Mano	T
99	T1S,	R98W	S9 , NW¼ NW¼					Mano fragment	T
100	T1S,	R99W	S21, SE¼ SW¼				5	Mano fragment	T
101	T1S,	R99W	S21, SW¼ NE¼	1					T
102	T1S,	R99W	S21, NE¼ NW¼			1f			T
129	T1S,	R98W	S32, NW¼ NE¼	5f	1f	3f	88		S
130	T1S,	R98W	S9 , NE¼ SE¼					1 Mano in 2 fragments	T
131	T1S,	R98W	S9 , SE¼ SE¼					1 Mano fragment	T
132	T1S,	R98W	S9 , SE¼ SE¼		1f	1f	14		T
133	T1S,	R98W	S10, SW¼ SW¼					Mano fragment	T
134	T1S,	R98W	S9 , SE¼ SW¼				5		T
135	T1S,	R98W	S21, NE¼ SW¼				1		T
136	T1S,	R98W	S22, NW¼ NW¼				1		T
137	T1S,	R98W	S22, NE¼ NW¼	1f				Toolstone fragment	T
138	T1S,	R98W	S21, SW¼ SW¼	1f	1f		2	Mano fragment	T
139	T1S,	R98W	S10, SW¼ SE¼		1f	1	49		T
140	T1S,	R98W	S9 , NE¼ NW¼	3f	3f	4 1f	90	Drill, 5 tool fragments, Mano, 4 Mano fragments, toolstone	P
141	T1S,	R98W	S9 , NW¼ NE¼	1f	1f	2	7		S
142	T1S,	R98W	S10, NW¼ NW¼			1	1	3 potsherds, core, hammerstone, Mano, 10 Mano fragments	S
144	T1S,	R98W	S10, NW¼ NE¼	1f	1f	3f	28	Mano fragment	S
145	T1S,	R98W	S10, NW¼ SW¼	1f		5f	14		S

Table 2.5.2-5 (Continued)

Field Number	Township	Range	Section	Tool Type					Site Classification
				Point	Knife	Scraper	Flakes	Other	
146	T1S,	R98W	S10, SE¼ NE¼	1f	1f	1	35	Chopper, 3 Mano fragments, 13 small blue trade beads, 2 small white trade beads, 1 blue bead	S
147	T1S,	R98W	S10, SE¼ NE¼		1f	3			
						4f	22		S
148	T1S,	R98W	S11, NW¼ NW¼	2f	2f		52	1 gray sandstone bead	S
149	T2S,	R98W	S4 , SW¼ SW¼			1	3	1 potsherd	T
150	T1S,	R98W	S32, NE¼ SE¼			1f	6		T
151	T1S,	R98W	S33, SW¼ SE¼	2f	1f	4f	42		S
152	T1S,	R98W	S11, NW¼ SE¼	1		1	13	Mano, hammerstone, 1 hammerstone fragment	S
153	T1S,	R98W	S11, NE¼ NE¼	1f	4f	6	51	Mano fragment	P
154	T1S,	R98W	S2 , SW¼ SW¼	1		1			
				2f	1f	1f	89		S
155	T1S,	R98W	S2 , SW¼ SW¼				5		T
156	T1S,	R98W	S2 , SW¼ SW¼				3	Mano fragment petrified bone	T
157	T1S,	R98W	S2 , NE¼ SW¼				20	Petrified bone	T
158	T1S,	R98W	S21, SW¼ NW¼				6	Petrified bone	T
159	T1S,	R98W	S11, NW¼ NW¼			4	9	Hammerstone, 2 Mano fragments	
						2f			T
160	T1S,	R98W	S16, NE¼ NE¼	3f	4f	1f	43	1 potsherd, 3 Mano fragments	S
161	T1S,	R98W	S16, SW¼ NE¼		1f		4		T
162	T1S,	R98W	S34, NW¼					Mano fragment	T
163	T1S,	R98W	S33, NE¼ NE¼		1f		2	Mano fragment	T
164	T1S,	R98W	S8 , NE¼ NE¼ S9 , NW¼ NW¼	2f	3f	1f	12	Hammerstone, 4 Mano fragments, chopper	S
165	T1S,	R98W	S16, SE¼ SE¼	2f	1f		6	Core	S
166	T1S,	R98W	S1 , SW¼ NW¼		1	1	10	Mano, hammerstone	S
167	T1S,	R98W	S35, NW¼ SW¼	1f	1f		3	Core, Mano fragment	S
168	T2S,	R98W	S2 , SE¼ SE¼	1f			3		T

Table 2.5.2-5 (Continued)

Field Number	Township	Range	Section	Tool Type					Site Classification
				Point	Knife	Scraper	Flakes	Other	
169	T1S,	R97W	S19, SW¼ SW¼				2	Mano fragment	T
170	T1S,	R97W	S18, SE¼ NW¼				1		T
171	T1S,	R98W	S29, NE¼ NE¼				3		T
172	T1S,	R98W	S28, NW¼ NW¼				3		T
173	T2S,	R98W	S6 , NW¼ NW¼			1,2f	5		T
174	T1S,	R98W	S31, SW¼				8		S
175	T1S,	R98W	S31, NW¼ NE¼	3f	1f	2f	34	Mano, Mano fragment, 5 tool fragments	S
176	T1S,	R98W	S31, NE¼ NE¼		1f	1	7	Core	S
177	T1S,	R98W	S32, NW¼ NW¼	4f	2f	2	74	Core tool	P
178	T2S,	R98W	S6 , NE¼ NE¼	1f		1			S
179	T1S,	R98W	S32, NW¼ SW¼	1f			3	Tool fragment	T
180	T1S,	R98W	S31, NW¼ SE¼	1f			2	Tool fragment	T
181	T1S,	R98W	S32, SW¼ NE¼		2f		11	Tool fragment	S
182	T1S,	R98W	S31, SE¼ SE¼		1f		42		S
183	T2S,	R99W	S14, NE¼ SW¼					Tool fragment	T
184	T2S,	R99W	S23, NE¼ SW¼				1	Tool fragment	T
185	T2S,	R98W	S19, NW¼ SW¼				1	Tool fragment	T
186	T1S,	R98W	S1 , NW¼ NE¼	3f	1f	4f	40	Hammerstone, Mano fragment, 3 tool fragments	S
187	T1S,	R98W	S36, E½			1f	7	Hammerstone, Mano	S
188	T1N,	R98W	S24, SE¼ SE¼	1f	1f	2	15	5 tool fragments, hammerstone	S
189	T2S,	R98W	S3 , NW¼	1f	1f	1	42	2 tool fragments	S
190	T2S,	R98W	S4 , SE¼ NE¼	1f	2f	3	42	2 toolstone fragments	S
191	T2S,	R98W	S3 , NE¼ NW¼	1 1f		1f	11	1 Mano fragment, 2 tool fragments	S
192	T1N,	R98W	S23, NW¼ NW¼		1		1		T
193	T1N,	R98W	S24, NE¼ NW¼	1f		1	16	Tool fragment	S
194	T1N,	R98W	S13, W½	2f		1	8	1 core tool, 1 hammerstone fragment, 1 Mano fragment	S

Table 2.5.2-5 (Continued)

Field Number	Township	Range	Section		Tool Type					Site Classification
					Point	Knife	Scraper	Flakes	Other	
195	T1S,	R98W	S34, SW¼	SE¼	1					T
196	T1N,	R98W	S13, SE¼	NE¼		1 1f	2f	4	Mano, Mano fragments, 3 tool fragments, 4 petrified bone fragments	T

f = Identifiable fragmentary tool

P = Primary site

S = Secondary site

T = Tertiary site

[1] = Sites off-tract other than 84 Mesa or the 1-mile perimeter

[2] = Cultural affiliations of off-tract sites are not yet available

Occupation of the area was probably limited to summer and fall because of food scarcity during spring and harsh weather conditions (in combination with lack of sheltered areas) in winter.

Major means of subsistence were hunting and gathering. The social unit was probably a family unit spanning two or three generations who shared food gathering activities. The unit was migratory, moving from place to place in search of adequate food and shelter.

Recent historic material reflects the wide use of the area by deer hunters. Current Anglo occupation is concentrated in the Ryan Gulch and Yellow Creek areas.

2.5.3 Revegetation

The revegetation program for RBOSP Tract C-a is designed to investigate current revegetation technology and develop a plan to successfully re-establish a plant community on the processed oil shale disposal pile in accordance with the environmental stipulations as described in the Federal Register, Volume 39, Number 230, Part 3, Oil Shale Lease Environmental Stipulations. This revegetation plan will be developed as a result of extensive field experiments and laboratory studies designed to provide data pertinent to Tract C-a.

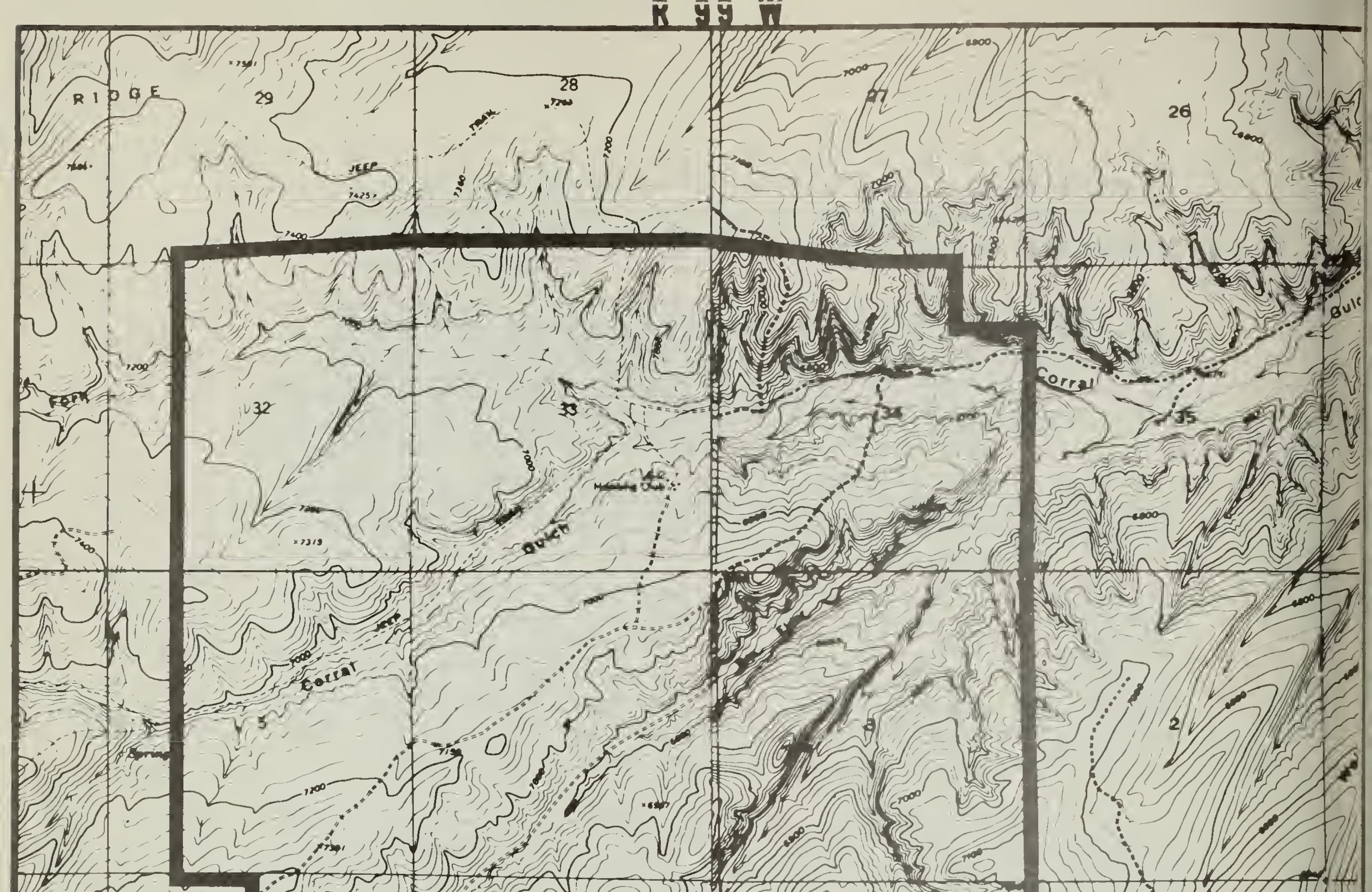
The location of the revegetation experimental plots is in the southeast corner of Tract C-a as shown in Figure 2.5.3-1. The revegetation test sites (locations R-1 and R-2, Figure 2.5.3-1) were selected to represent opposing slope aspects at elevations between 7100 and 7200 feet with slopes approximating 3:1. Trials in each of the two subsequent years will utilize a single site on the slope having the most extreme drought conditions.

Several revegetation studies are currently being conducted in the Piceance Creek Basin. These studies deal both with problems of revegetating processed oil shale and with selection of appropriate revegetation methods for vegetation types similar to those existing on Tract C-a.

2.5.3.1 Objectives

Revegetation experiments are designed to determine the following:

- which species when sown in a composite species mixture are most adapted to the physical and environmental conditions existing on Tract C-a,
- effectiveness of several mulches in aiding establishment of sown plant species and in reducing erosion,
- effects of fertilizer applied at different time periods on sown plant species, and
- effects of aspect on the establishment of the sown species.



LEGEND

▬ TRACT OUTLINE

■ 1975 REVEGETATION TEST PLOTS

GULF - STANDARD (INDIANA)

RIO BLANCO OIL SHALE PROJECT

TRACT C-a

RIO BLANCO COUNTY, COLORADO

0 3000

2.5.3.2 Methods

A detailed description of methods utilized in the revegetation program is presented in Section 2.5.3.2 of Progress Report 4 - Summary (October 1975). Methods for the revegetation program remain unchanged since the publishing of this report, except for the deletion of snowberry (*Symphoricarpos oreophilus*) from the list of plant species seeded on the revegetation plots.

2.5.3.3 Results

The RBOSP revegetation test plots were prepared and seeded during the period of November 3 - 14. Prior to clearing the sites in preparation for seeding, the vegetation at locations R1 and R2 was characterized (Daubenmire, 1968) (see Tables 2.5.3-1 and 2.5.3-2). Both locations occur in sagebrush vegetation dominated by *Artemisia tridentata*. These areas border on pinyon-juniper vegetation and small individulas of *Pinus edulis* and *Juniperus osteosperma* are scattered throughout. Location R1 appears more diverse since it contained a greater number of species (Table 2.5.3-1) when sampled in November but had less total cover than R2 (Table 2.5.3-2).

Soil samples were collected at each location for chemical analysis and soil moisture determinations. Chemical analyses of the soils are not yet completed. Soil moisture determinations (Tables 2.5.3-3 and 2.5.3-4) indicate that soils on the southeast (R2) facing slope at 30 cm and 45 cm depths were drier than those of the northwest (R1) facing slopes. Soils at the surface and at the 15 cm depth on R2 had slightly higher moisture contents than those of R1. These data show only the relationship that existed on November 4 and 5, 1975. A more accurate accounting of soil moisture relationships will be gained as more seasonal soil moisture data are compiled during the course of the revegetation studies.

The earliest results of the actual revegetation experiments will be collected in the spring of 1976. Statistical analyses for the revegetation experimental program for rehabilitation of RBOSP Tract C-a disposal piles will analyze the following dependent variables: 1) number of emerged seedlings early in the first growing season, 2) number of surviving seedlings at the end of the first growing season, 3) above ground biomass of vegetation harvested after the third growing season and 4) percent cover at the end of each growing season.

Table 2.5.3-1. Relative abundance of the vegetation present on the RBOSP revegetation site R1 on November 4, 1975 prior to planting.

Plant Species	Relative Abundance*
Artemisia tridentata	5
Phlox hoodii	3
Grindelia squarrosa	3
Pinus edulis	2
Oryzopsis hymenoides	2
Chrysothamnus depressus	2
Comandra umbellata	2
Amelanchier cf. *utahensis*	2
Chrysothamnus nauseosus	1
Ipomopsis aggregata	1
Penstemon osterhoutii	1
Lupinus argenteus	1
Opuntia polyacantha	1
Arenaria fendleri	1
Agropyron trachycaulum	1
Stipa comata	1
Sphaeralcea coccinea	1
Senecio multilobatus	1
Eriogonum ovalifolium	1
Purshia tridentata	1
Festuca ovina	1
Koeleria cf. *cristata*	1
Symphoricarpos oreophilus	1
Juniperus osteosperma	1
Astragalus lambertii	1
Eurotia lanata	1
Sisymbrium sp.	1
Chaenactis sp.	1
Psoralea sp.	1
Physaria sp.	1
Eriogonum sp.	1
Bryophyte	1

Total Cover = 40%

*Relative Abundance:
1 = very rare
2 = rare
3 = occasional to common
4 = abundant
5 = very abundant

Table 2.5.3-2. Relative abundance of the vegetation present on the RBOSP revegetation site R2 on November 3, 1975 prior to planting.

Plant Species	Relative Abundance*
Artemisia tridentata	4
Chrysothamnus viscidiflorus	3
Oryzopsis hymenoides	3
Phlox hoodii	2
Purshia tridentata	2
Agropyron trachycaulum	2
Senecio multilobatus	2
Juniperus osteosperma	1
Pinus edulis	1
Stipa comata	1
Penstemon osterhoutii	1
Chrysothamnus depressus	1
Grindelia squarrosa	1
Salsola kali	1
Ipomopsis aggregata	1
Chrysothamnus nauseosus	1
Phacelia sericea	1
Opuntia polyacantha	1
Hymenopappus filifolius	1
Amelanchier cf. *utahensis*	1
Psoralea sp.	1
Physaria sp.	1
Astragalus sp.	1
Antennaria sp.	1
Chaenactis sp.	1
Cryptantha sp.	1
Bryophyte	1

Total Cover = 45%

*Relative Abundance:
1 = very rare
2 = rare
3 = occasional to common
4 = abundant
5 = very abundant

Table 2.5.3-3. Soil moisture in percent water* for location R1 (November, 1975).

Sample No.	Soil Depth			
	0 cm	15 cm	30 cm	45 cm
R1/1	21.65	27.03	23.64	Bedrock
R1/2	16.33	17.65	15.00	10.86
R1/3	12.21	22.01	14.26	10.57
Composite (R1/1, R1/2, R1/3)	16.62	22.11	17.48	10.70

*Black (1965). $\frac{\text{(weight of wet soil + tare) - (weight of dry soil + tare)}}{\text{(weight of dry soil + tare) - (tare)}}$

Table 2.5.3-4. Soil Mositure in percent water* for location R2 (November, 1975).

Sample No.	Soil Depth			
	0 cm	15 cm	30 cm	45 cm
R2/1	16.77	16.55	10.72	10.13
R2/2	18.43	23.03	8.27	Bedrock
R2/3	24.63	30.14	15.00	Bedrock
Composite (R2/1, R2/2, R2/3)	19.85	22.99	11.26	10.13

*Black (1965). $\frac{\text{(weight of wet soil + tare) - (weight of dry soil + tare)}}{\text{(weight of dry soil + tare) - (tare)}}$

Statistical computations will be performed in each year for each of the sixteen treatments at each location; for each of the planted species; and for each treatment and species combination.

An analysis of variance is performed for each of the dependent variables. Certain assumptions and partitions for the analysis are presented in Tables 2.5.3-5 and 2.5.3-6 in abridged form and in Table 2.5.3-7 in unabridged form along with the expected mean squares. The expected mean squares are included for demonstrating what assumptions are made and what denominators are used in constructing the F ratios for testing. Throughout the discussion it is assumed that the data will permit a balanced design (no empty sub-classes or empty treatment cells).

Table 2.5.3-5 is an abridged table of the analysis of variance. In this table, Error (B) has two assumptions associated with it. Error (B) is a composite term that estimates three variance components, σ_e^2, σ_{BS}^2 and σ_{BTS}^2 (Graybill, 1961). If the last two variance components are not equal to zero, the use of Error (B) in testing leads to negatively biased tests. A suitable alternative is to partition Error (B) into these components. The expected mean squares {E(MS)} for this partition are:

Source	Degrees of Freedom	E(MS)
Error (B)	672	σ_e^2
Block x Species	42	$\sigma_e^2 + nt\sigma_{BS}^2$
Block x Treatment x Species	630	$\sigma_e^2 + n\ \sigma_{BTS}^2$

By using the above partition of Error (B), no assumption above either σ_{BS}^2 and σ_{BTS}^2 is made. Table 2.5.3-6 shows the above partition incorporated into the abridged analysis of variance.

The expected mean squares in Table 2.5.3-6 suggest which mean squares are the appropriate denominator for testing hypotheses. Three F ratios are given Table 2.5.3-7 and are appropriate for testing i) whether there exist differences among treatments, ii) whether there exist differences among the species of plants, and iii) whether differences among treatments are the same for all species.

The computer programs which will be used in performing statistical analyses include programs selected from those of the Statistical Analysis System developed by North Carolina State University (Barr & Goodnight, 1972).

Table 2.5.3-5. Expected values of mean squares.

	Source of Variation	Degrees of Freedom		E(MS)	F Ratio
1	Block	2	b-1	$\sigma_e^2 + stn\sigma_B^2$	
2	Treatment	15	t-1	$\sigma_e^2 + sn\ \sigma_{BT}^2 + bsn\kappa_T^2$	(2/3)
3	Error (A)	30	(b-1)(t-1)	$\sigma_e^2 + sn\ \sigma_{BT}^2$	
4	Species	21	s-1	$\sigma_e^2 + btn\ \kappa_S^2$	(4/6)
5	Treatment x Species	315	(t-1)(s-1)	$\sigma_e^2 + bn\ \kappa_{TS}^2$	(5/6)
6	Error (B)	672	t(b-1)(s-1)	σ_e^2	
	Total	1055			

σ^2 = the population variance of true random effects

κ^2 = the quadratic function of differences among the true fixed effects

Table 2.5.3-6. Expected values of mean squares.

	Source of Variation	Degrees of Freedom		E(MS)	F Ratio
1	Block	2	b-1	$\sigma^2_e + stn\sigma^2_B$	
2	Treatment	15	t-1	$\sigma^2_e + sn\ \sigma^2_{BT} + bsn\kappa^2_T$	(2/3)
3	Error (A)	30	(b-1)(t-1)	$\sigma^2_e + sn\ \sigma^2_{BT}$	
4	Species	21	s-1	$\sigma^2_e + tn\ \sigma^2_{BS} + btn\ \kappa^2_S$	(4/6)
5	Treatment x Species	315	(t-1)(s-1)	$\sigma^2_e + n\sigma^2_{BTS} + bn\ \kappa^2_{TS}$	(5/7)
6	Block x Species	42	(b-1)(s-1)	$\sigma^2_e + tn\ \sigma^2_{BS}$	
7	Block x Species x Treatment	630	(b-1)(s-1)(t-1)	$\sigma^2_e + n\ \sigma^2_{BTS}$	
	Total	1055			

σ^2 = the population variance of true random effects

κ^2 = the quadratic function of differences among the true fixed effects

Table 2.5.3-7. Analysis of variance, degrees of freedom and F ratios.

	Source of Variation	Degrees of Freedom	F Ratio
1	Block	2	
2	Mulch	3	2/5
3	Fertilizer	3	3/6
4	Mulch X Fertilizer	9	4/7
5	Block X Mulch	6	
6	Block X Fertilizer	6	
7	Block X Mulch X Fertilizer	18	
8	Species	21	8/12
9	Mulch X Species	63	9/13
10	Fertilizer X Species	63	10/14
11	Mulch X Fertilizer X Species	189	11/15
12	Block X Species	42	
13	Block X Mulch X Species	126	
14	Block X Fertilizer X Species	126	
15	Block X Mulch X Fertilizer X Species	378	
16	Total	1055	

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2.5.4 Toxicology

The toxicology studies are outside the scope of the environmental baseline program, therefore discussion of this program is omitted. It will be discussed under human health and safety in Section 9 Chapter 2 of the DDP.

2.5.5 Trace Metals

Trace metals are known to occur in the biosphere; however, the level of certain trace metals has increased in recent years as industrial development has increased. These trace metals, often by-products of industrial processes, can enter the ecosystem through the air, soil, or water. Certain trace elements are essential to plants and animals in low concentrations. In addition, some metals can produce synergistic (compounded) effects when occurring with other metals. Conversely, the presence of one metal can reduce the toxicity of another. Despite recent research in this area, most questions concerning the effects of trace metals on ecosystems are unanswered, as evidenced by the paucity of available literature on trace metal cycling in the semi-arid west.

A number of factors influence the potential toxicity of any given metal in a dynamic system. They include:

- soil texture
- soil moisture availability
- the nature of the metal (free or bound)
- evapotranspiration rates
- the species of plant or animal
- seasonal fluctuations
- the presence or absence of other constituents (organic and/or inorganic)
- age of organism or stage of life cycle

These factors may independently or collectively effect cycling of trace metals in an ecosystem.

2.5.5.1 Objectives

The initial goals of this program are to identify the presence and concentration of baseline levels of trace metals in the soil. This information, in conjunction with soil data (e.g., texture, soil moisture release curves) and available literature, will be used to determine if further studies should be conducted.

2.5.5.2 Methods

Methods for analyzing soils samples were described in Section

2.5.1.2, Progress Report 2 - Summary. Should further analysis for trace metals be deemed necessary, the first step will involve analysis of local plants. Following data analysis and interpretation, another judgement will be made on the advisability of sampling plant-eating animals for the presence of accumulated trace metals. These steps will be repeated as necessary until baseline trace metal levels have been determined.

2.5.5.3 Results

The biological effects of some trace metals which are applicable to the environs of Tract C-a have been identified from previous work and a detailed literature review. Oil shale development has been associated with abnormally high levels of molybdenum, zinc, fluoride, and selenium. These four chemical constituents can affect both terrestrial and aquatic ecosystems, if present in sufficient amounts. It will be difficult to determine their effects on the environs associated with Tract C-a until their exact background concentrations are known.

a. Molybdenum

Molybdenum is essential in low concentrations for healthy growth of some plants, and it also acts as an enzymatic catalyst for nitrate reduction in certain microbiological systems (McKee and Wolf 1963). Many legumes cannot complete their life cycle if the soil is deficient in molybdenum, since the functioning of nitrate-producing mechanisms depends on this element (Browning 1961).

Molybdenum has been shown to be injurious to certain plants at higher concentrations. Injurious effects of various concentrations of molybdenum on domestic food crops are presented below:

Plant	Effect	Concentration in mg/liters of Molybdenum	Reference
Flax	Abnormal growth	0.5-100	Millikan 1949
Clover, Lettuce	Toxic effect	5.0	Joham 1953
Soybean	Toxic effect	10-20	Warington 1950
Cotton	Slight effect	25-35	Joham 1953
Oats	Slight effect	50	Hunter, Vergano 1953
Oats	Chlorosis	100	Hunter, Vergano 1955
Oats	Stunted growth	200	Hunter, Vergano 1953

Animals require trace amounts of molybdenum for proper metabolic functioning, but high concentrations tend to be toxic. Browning (1961) indicated the LD_{50} (the dose at which 50% of test animals die during a given period of time) for rats was 125 mg/kg for molybdenum trioxide, 101 mg/kg for calcium molybdate, and 333 mg/kg for ammonium molybdate. When the toxic compounds containing molybdenum were compared, the following results were noted. When 500 mg of molybdenite (MoS_2) was ingested daily, there was no reportable toxic effect; but, animals receiving the same dosage of molybdenum trioxide, calcium molybdate, or ammonium molybdate showed anorexia, listlessness, and loss of weight. Molybdenum increased the mortality rate of rats fed a ration containing 11 mg/l of selenium in their drinking water (Moxan and Rhian 1943). Chicks fed a diet containing 300 mg/l (dry basis) of molybdenum experienced reduced growth rates during a 4-week period and then resumed near normal growth. Chicks administered 600 mg/l experienced suppressed growth through 8 weeks (Arthur et al. 1958). Copper, however, appeared to antagonistically reduce the toxicity of molybdenum.

The principle impact of molybdenum to herbivores results from its rapid incorporation by plants into their foliage. Water-soluble molybdenum compounds in herbage cause severe cases of scour in cattle. Pastures where cattle had severe scour (caused by molybdenum) contained 20 to 100 mg/l of molybdenum, while pastures where cattle were not subject to scour contained less than 5 mg/l (Russell 1944).

In aquatic systems, Tarzwell and Henderson (1956) determined in an exploratory test using molybdic anhydride that the 96-hour TL_m (concentration which kills 50% of test animals in 96 hours) for fathead minnows was 70 mg/l in soft water (pH = 7.4, total alkalinity = 18, hardness = 20) and 730 mg/l in hard water (pH = 8.2, total alkalinity = 360, hardness = 400). Molybdenum appears to be essential for the growth of the green algae Scenedesmus sp., with the threshold concentration for deleterious effect being 54 mg/l (Arnon and Wessel 1953). Both the gram-positive bacteria Escherichia coli and the aquatic crustacean Daphnia sp. tolerated concentrations of 1000 mg/l without perceptible injury (Bringmann and Kuhn 1959).

b. Zinc

The biological effect of zinc varies from compound to compound and the physical and chemical conditions in the environment. Zinc salts such as zinc chloride and zinc sulfate are highly soluble in water. On the other hand, zinc carbonate and zinc oxide are highly insoluble and are readily precipitated and removed from natural waters.

Zinc occurs in many species of plants in amounts varying from 1 to 10 mg/kg (Browning 1961). Zinc in higher concentrations, however, can have a deleterious effect upon plants. Tomlinson (1956) indicated that the germination of cress and mustard seeds in an aqueous solution was retarded by the addition of 54 to 436 mg/l of zinc to the growth medium.

Zinc toxicity in animals is determined by size, age, and species. Anderson et al. (1934) found that rats showed no harmful effects when fed 50 mg/l of zinc in their water. In pigs (Anon 1950), 390 mg/l of zinc fed over 3 months produced no ill effect; however, when 1000 mg/l of zinc was fed as lactate, it caused lameness and malnutrition. In the domestic cat, there was no reportable injury when fed 5 mg/l of zinc as malate per day for 10 days (Moxan and Rhian 1943). When water-soluble zinc was ingested by laying hens at a concentration of 10,000 mg/l, egg production dropped and water consumption decreased (Sturkie 1956).

Zinc exhibits its greatest toxicity to fish and aquatic organisms. Jones (1938) reported that the lethal limit of zinc in mature fish varies with the amount of calcium in the water. Apparently zinc forms insoluble compounds with the mucous on gill covers (Southgate 1955), damages gill epithelium (Lloyd 1960), or possibly acts as an internal poison (Kruse 1958).

Copper seems to increase the toxicity of zinc in natural waters. Doudoroff and Katz (1953), Doudoroff (1952, 1957), and Tarzwell (1956) observed that test fish in soft water could tolerate a concentration of 8 mg/l of zinc for 8 hours. However, when 0.025 mg/l copper was combined with 1 mg/l of zinc in solution, all fish died within 8 hours (Doudoroff 1957). In addition to the zinc-copper interaction, Doudoroff (1952, 1956) reported that zinc increased the toxic properties of cyanide by allowing dissociation of this zinc-cyanide complex in very dilute solutions.

c. Fluorides

Fluorides are also potentially toxic. They are seldom found in natural waters because of their origin in certain types of rock and tendency to precipitate out in the presence of oxygen, but they do occur in high concentrations in ground water. The possibility of pumping ground waters to the surface during open-pit mining operations exists, thereby creating a potential hazard.

It has been reported that concentrations of fluoride in natural waters or in polluted streams have no detrimental effect on plants (Russell 1944, MacIntire et al. 1951, Smith et al 1945). In animals, low concentrations help retard tooth decay, but higher concentrations cause mottling of the teeth. In lactating cows, ingested of low concentrations of fluoride had no influence on fluorides in the milk. When 500 mg/l (Smith, et al. 1945) was ingested it increased fluorides in the milk by only 0.5 mg/l; however, chronic fluoride poisoning of livestock has been observed where water contained 10 to 15 mg/l fluoride (Servisis, unpublished data).

d. Selenium

Although selenium in trace amounts appears to be essential for the nutrition of animals, very little is known about the mechanism of its action.

In general, the soil in parts of the world where selenium poisoning occurs naturally contains 1 to 6 mg/kg of selenium in the top 20 cm (8 in). Not all such soils give rise to toxic vegetation, due in part to differences in the solubility of the selenium compounds present, their availability to plants, and the plants' ability to absorb selenium. Where poisoning is prevalent, samples of vegetation have been found to contain as little as 1 mg/kg of selenium. Final selenium concentrations in plants are determined by many factors including the species and age of the plant, season of the year, and the concentration of soluble selenium compounds in the root zone.

Plants can absorb relatively large amounts of selenium from irrigation water or soil without apparent injury to themselves. Plants grown on seleniferous soil have been found to contain as much as or more than 1610 mg/kg of selenium (dry weight) (Miller and Byers 1936). Certain weeds such as Astragalus may contain as much as 4500 mg/kg of selenium (Russell 1944). Byers (1935) believes that any vegetation containing 5.0 mg/kg of selenium is potentially dangerous as feed, while any soil containing more than 0.5 mg/kg is hazardous. Russell (1944) has pointed out that while fodder containing as little as 1 mg/kg of selenium has caused poisoning, 4 mg/kg appears to be the tolerance for livestock.

Selenium poisoning ("alkali disease" or "blind staggers") occurs frequently among livestock in the Great Plains regions of the United States, Canada and Mexico (Russell 1944). It occurs in livestock as a result of feeding on abnormal amounts of inorganic selenium compounds or seleniferous feed. Generally, the toxicity level will be determined primarily by the soil type and plant community in question.

Selenium poisoning (chronic and acute) occurs naturally among cattle, sheep, horses, pigs, and poultry. In the mammals, it is characterized by loss of hair from mane and tail, soreness of the feet, deformity, loss of condition, and emaciation. Among poultry, selenium poisoning causes abnormal and/or weak chicks.

In the aquatic environment, it is believed that selenium is passed up through the food chain to the fish, which accumulate this element in the liver in lethal concentrations. Barnhart (1958) described a reservoir in Colorado that has been stocked repeatedly with a variety of game fishes, only to have the fish die within a few weeks. Tests have shown that bottom deposits in the reservoir contain high concentrations of selenium.

In goldfish, 2.0 mg/l of selenium added as sodium selenite has been toxic in 8 days and lethal in 18 to 46 days (Anon. 1950). Minute concentrations of selenium do not appear to be harmful to fish during an exposure period of several days; however, constant exposure to traces of selenium for several weeks has caused disturbances of appetite and equilibrium, pathological changes, and even death.

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2.5.6 Visibility Studies

Joint visibility studies are discussed in Section 2.2.3.5b of this report.

2.5.7 Seismicity

The results of the seismicity study were presented in Progress Report 3 - Summary. No additional work has been done.

2.5.8 Paleontological Survey

2.5.8.1 Objective

The objective of this program is to estimate the potential for a significant paleontological discovery within or immediately adjacent to Tract C-a during tract development. A significant discovery is here defined as one which is unique to the area or one in which an unusually large concentration of well preserved fossils is located.

2.5.8.2 Methods

Geologists involved in the surface geologic mapping program (structure mapping by plane table and alidade methods, stratigraphic section lithologic descriptions) were constantly on the alert for paleontologic finds. In addition, the other contractors involved in the various baseline data gathering programs in and around Tract C-a were instructed to report all paleontological finds. These contractors include those charged with archaeological investigations, ecological investigations and the core hole program. A brief literature search was also made.

2.5.8.3 Results

No significant paleontological finds have been observed on the surface in or around Tract C-a. Geologists involved in the surface geologic mapping program encountered only small plant remains, mainly fragmental, scattered throughout the outcrops of the upper Parachute Creek Member, Green River Formation. Remains of this type are relatively common throughout the Piceance Creek basin. No fossils were observed in the overlying Uinta Formation.

A review of tract core hole lithologic description logs disclosed the presence of sparse small fish remains below the Blue marker in the Garden Gulch Member in three G-S core holes, Nos. 9, 13 and 15 (see tract cross section, Fig. 3-3-4, Sec. 3, Chap. 3). No other vertebrates were observed in the subsurface. These fish remains are not unique to Tract C-a.

Brobst and Tucker (1973, p. 8-12) located fish remains at the "pipeline" outcrop section on Cathedral Bluffs about five miles southwest of Tract C-a. Cashion (1967, p. 13 & 16) report their presence in the Parachute Creek and Garden Gulch Members in both the Piceance Creek and Uinta basins of Colorado and Utah, respectively.

Also, Brobst and Tucker reported turtle and insect remains and a catfish skull at the "pipeline" section in oil shales above the Mahogany zone. No such fossils have been found within or in the immediate vicinity of Tract C-a.

By definition, Green River oil shale contains variable amounts of organic matter derived chiefly from micro-organisms and is therefore inherently fossiliferous. Two kinds of organic matter are distinguishable in thin sections of oil shale (Bradley, 1931, p. 39). One is paleontologically structureless (amorphous) and makes up the vast majority of oil shale's organic fraction. The second consists of complete or fragmentary micro-organisms such as algae, protozoa and insects and parts of higher plants such as spores, pollen grains and minute pieces of tissue. Microfossil remains of these organisms are indigenous to oil shale throughout the basin. Megafossils, such as the previously mentioned turtle and fish remains, are locally present scattered throughout various horizons in the oil shale sequence.

Although a significant paleontologic discovery is always a possibility during any excavation in or adjacent to Tract C-a, that possibility is considered extremely remote based on the data compiled.

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